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MISCELLANEOUS COLLECTIONS

VOL. XLIV

"EVERY MAN IS A VALUABLE MEMBER OF SOCIETY WHO BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS PROCURES KNOWLEDGE FOR MEN."—SMITHSON.

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S. P. LANGLEY,
Secretary S. I.

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Azores (*via* Portugal).
Belgium: Service Belge des Échanges Internationaux, Brussels.
Bolivia: Oficina Nacional de Inmigración, Estadística y Propaganda Geográfica, La Paz.
Brazil: Serviço de Permutações Internacionaes, Bibliotheca Nacional, Rio de Janeiro.
*British Colonies: Crown Agents for the Colonies, London.
Bulgaria: Doctor Paul Leverkühn, Sofia.
Canada: Sent by mail.
Canary Islands (*via* Spain).
Cape Colony: Superintendent of the Stationery Department, Cape Town.
Chile: Universidad de Chile, Santiago.
China: Shipments temporarily suspended.
Colombia: Biblioteca Nacional, Bogotá.
Costa Rica: Oficina de Depósito y Canje de Publicaciones, San José.
Denmark: Kongelige Danske Videnskabernes Selskab, Copenhagen.
Dutch Guiana: Surinaamsche Koloniale Bibliotheek, Paramaribo.
Ecuador: Biblioteca Nacional, Quito.
East India; India Store Department, India Office, London.
Egypt: Société Khédiviale de Géographie, Cairo.
France: Bureau Français des Échanges Internationaux, Paris.
Friendly Islands: Sent by mail.
Germany: Doctor Felix Flügel, Äussere Halle'sche Strasse No. 18, Leipzig-Gohlis.
Great Britain and Ireland: Messrs. William Wesley & Son, 28 Essex Street, Strand, London.
Greece: Professor R. B. Richardson, Director American School of Classical Studies, Athens.
Greenland (*via* Denmark).
Guadeloupe (*via* France).
Guatemala: Instituto Nacional de Guatemala, Guatemala.
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Haiti: Secrétaire d'Etat des Relations Extérieures, Port au Prince.
Honduras: Biblioteca Nacional, Tegucigalpa.
Hungary: Doctor Joseph von Körösy, "Redoute," Budapest.
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Newfoundland : Sent by mail.
New South Wales : Government Board for International Exchanges, Sydney.
New Zealand : Colonial Museum, Wellington.
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Norway : Kongelige Norske Frederiks Universitet, Christiania.
Paraguay : Ministerio de Relaciones Exteriores, Asuncion.
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Peru : Biblioteca Nacional, Lima.
Portugal : Bibliotheca Nacional, Lisbon.
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South Australia : Astronomical Observatory, Adelaide.
Spain : Oficina para el Canje de Publicaciones Oficiales, Cientificas y Literarias, Seccion de Propiedad Intelectual del Ministerio de Fomento, Madrid.
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Sweden : Kongliga Svenska Vetenskaps Akademien, Stockholm.
Switzerland : Service des Échanges Internationaux, Bibliothèque Fédérale Centrale, Bern.
Tasmania : Royal Society of Tasmania, Hobart.
Tunis (*via* France).
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Uruguay : Oficina de Depósito, Reparto y Canje Internacional, Montevideo.
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SMITHSONIAN MISCELLANEOUS COLLECTIONS.

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INDEX TO THE LITERATURE

OF

THORIUM.

1817-1902.

BY

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CITY OF WASHINGTON:
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1903.

WASHINGTON, D. C.
PRESS OF JUDD & DETWEILER
1903

LETTER OF TRANSMITTAL.

WASHINGTON, D. C., *October 9, 1902.*

The Committee on Indexing Chemical Literature, appointed in 1882 by the American Association for the Advancement of Science, has voted to recommend to the Smithsonian Institution for publication the following:

"INDEX TO THE LITERATURE OF THORIUM,

by Cavalier H. Joüet, Ph. D."*

HENRY CARRINGTON BOLTON,
Chairman.

Mr. S. P. LANGLEY,
Secretary of Smithsonian Institution.

*This forms one of the following series:

Index to the Literature of Uranium, 1785–1885, by Henry Carrington Bolton, 1885.

Index to the Literature of Columbium, 1801–1887, by Frank W. Traphagen, 1888.

Index to the Literature of the Spectroscope, by Alfred Tuckerman, 1888, 1902.

Index to the Literature of Thermodynamics, by Alfred Tuckerman, 1890.

A Bibliography of the Chemical Influence of Light, by Alfred Tuckerman, 1891.

A Bibliography of Aceto-Acetic Ester, by Paul H. Seymour, 1894.

Index to the Literature of Didymium, 1842–1893, by A. C. Langmuir, 1895.

Indexes to the Literature of Cerium and Lanthanum, by W. H. Magee, 1895.

A Bibliography of the Metals of the Platinum Group, by Jas. Lewis Howe, 1897.

Review and Bibliography of the Metallic Carbides, by J. A. Mathews, 1898.

Index to the Literature of Thallium, 1861–1897, by Miss Martha Doan, 1898.

Index to the Literature of Zirconium, by A. C. Langmuir and Charles Baskerville, 1899.

A Bibliography of the Analytical Chemistry of Manganese, 1785–1900, by Henry P. Talbot and John W. Brown, 1902.

PREFACE.

This Index to the Literature of Thorium has been prepared after a very laborious and painstaking search through many scientific and technical journals.

Most of the references have been verified, and usually the original article heads the list, but in some few cases this was difficult to determine.

It is not offered as absolutely complete, and the compiler requests that any one using the index would send corrections and addenda to him.

Minerals now recognized as containing thorium have been mentioned only in such cases when the earth has been found. The patent literature relative to the use of thorium in the arts is not included.

C. H. J.

COLUMBIA UNIVERSITY,
NEW YORK, 1902.

INDEX TO THE LITERATURE OF THORIUM.

(1817–1902.)

BY CAVALIER H. JOÜET, Ph. D.

1817: 1. Gahn, Wallmann, Eggertz, Berzelius. Undersökning af nagra i trakten kring Fahlun funna Fossilier, och af deras Lagerställen.

Afh. Fys. Kemi, 1818, **5**, 1–93; Oken, Isis, 1819, col 391–409; J. für Chem. (Schweigger), 1817, **21**, 25–43; Ann. Phil. (Thomson), 1817, **9**, 160–161, 452–460; Ann. chim. phys., 1817, **5**, 5–21; Quart. Jour. Sci. Arts, 1817, **2**, 443; Ann. Mines, 1818, [**1**], **3**, 151–160; Roy. Soc. C. Sci. Papers, 1867, **1**, 340, and 1868, **2**, 457, 754.

1817: 2. Note. New earth discovery, Thorine.

Ann. Phil. (Thomson), 1817, **9**, 412.

1817: 3. Gahn. Thorine, eine neue Erde.

Oken, Isis, 1817, **1**, col 1317–1320; Roy. Soc. C. Sci. Papers, 1868, **2**, 754.

1817: 4. Bernhardi. Das allgemeine Krystallizations system der chemischen Elemente. "Thorinium."

J. für Chem. (Schweigger), 1817, **21**, 4–24; Roy. Soc. C. Sci. Papers, 1867, **1**, 304.

1818: 5. Berzelius. Chemische Entdeckungen im Mineralreiche gemacht zu Fahlun in Schweden, Thorina, eine neue Erde. "Nachricht von Herrn Berzelius neuer Erde, Thorina."

Ann. der Phys. Pogg., 1818, **59**, 247–254; Roy. Soc. C. Sci. Papers, 1867, **1**, 333.

1821: 6. Berzelius. Nya metalliska Kroppar. "Thorium."

Arsb. Phys. Kemi, 1821, 66; Berzelius' Jsb., 1822, **1**, 50; Archiv. Bergbau, 1823, **8**, 376.

1821: 7. Berzelius. Thorjord funnen pa Bornholm (now problematical).

Arsb. Phys. Kemi, 1821, 57; Berzelius' Jsb., 1822, **1**, 40.

1823: 8. Berzelius. Undersökning af flusspats-syran och dess märkvärdigaste föreningar. "Tillagg om Thorjorden" (proves to be yttrium phosphate).

Kongl. Sv. Vet. Acad. Handl., 1823, 284–359; 1824, 46–98, 278–328; Ann. chim. phys., 1824, **26**, 39–43; 1824, **27**, 53–67, 167–177, 287–308, 337–359; 1825, **29**, 295–314, 337–372; Ann. der Phys. Pogg., 1824, **1**, 1–48, 169–230; 1824, **2**, 113–150; 1825, **4**, 1–22, 117–156; Phil. Mag., 1824, 392–393; 1825, **65**, 254–267; J. für Chem. (Schweigger)

1825, **44**, 348–350; Arsb. Phys Kemi, 1825, 118; Berzelius' Jsb., 1826, **5**, 112, 113; Ann. Mines, 1826 [I], **12**, 190; Quart. Jour. Sci. Arts, 1825, **18**, 156, 157; Annals Phil. (Thomson), 1824, **8**, 330–343, 450–457; 1824, **9**, 124–131; 1824, **10**, 116–130; Roy. Soc. C. Sci. Papers, 1867, **1**, 335.

1825: 9. Lettre de M. Berzelius à M. Brogniart. March 15, 1825. Observations sur diverses espèces Minérales, extraites d'une lettre de M. Berzelius, à M. Brogniart.

Ann. des sci. naturelles, 1825, No. **5**, 430–432; Ann. Phil. (Thomson), 1826, **11**, 23–24; Edin. J. Sci., 1825, **3**, 332–334; Roy. Soc. C. Sci. Papers, 1867, **1**, 335.

1826: 10. Wöhler. Ueber den Pyrochlor, eine neue Mineral species "Ceroxyd" (unrein).

Ann. der Phys. Pogg., 1826, **7**, 417–428; Ztschr. Kryst, 1826, **2**, 385–389; Ber., 1882, **15**, 3150*a*; Berzelius' Jsb., 1828, **7**, 175–176: Arsb. Phys. Kemi, 1827, 172–173; Beudant. Min., 1832, vol. 2, 649, 756; Rammelsberg's Min. Chem., 1875, 2d ed., 371–375; Roy. Soc. C. Sci. Papers, 1872, **6**, 411.

1827: 11. Rose. Pyrochlore, a new mineral species.

Edin. J. Sci., 1827, **6**, 358–361.

1828: 12. Berzelius. Ueber den Thorit, ein neues mineral und eine darin enthaltene neue Erde, die Thorerde.

Ann. der Phys. Pogg., 1829, **15**, 633–634; Berzelius' Traité de Chimie, French ed., 1846, **2**, 179–184: Rammelsberg's Min. Chem., 1860, 544–546; Edin. J. Sci., 1829, **1**, 207–209; 1829, **2**, 223–225; Quart. Jour. Sci. Arts, 1829, **2**, 412–413; 1830, **1**, 88–104; 1830, **1**, 417–419; Gmelin-Kraut, Handb. anorg. Chemie, 1874–1886, II^1, 881; Heusmans, Repertoire, 1829, June; Phil. Mag., 1829, **6**, 392–393; Roy. Soc. C. Sci. Papers, 1867, **1**, 336.

1829: 13. Berzelius. Undersökning af ett nytt mineral som innehaller en förut obekant jord.

Kongl. Sv. Vet. Akad. Handl., 1829, 1–30; Berzelius' Lehrbuch d. Chemie, 1845, **3**, 1224; 1845, 5° Auf. **2**, 189–194; 1845, 5° Auf. **3**, 511–518; Ann. der Phys. Pogg., 1829, **16**, 385–414; Ann. chim. phys., 1830, **43**, 5–38; J. techn. Chem., 1829, **2**, 463–464; Bibl. Univ., 1829, n. s., **42**, 291–311; 1830, n. s., **43**, 48–64; Quart. Jour. Sci. Arts, 1829, **2**, 296–302; 1830, **1**, 88–104; Gmelin-Kraut, Handb. anorg. Chemie, 1875, **1**, 57; 1897, 2^2, 144, 226, 694, 976; Rammelsberg's Min. Chem., 1875, 2 Auf. **2**, 173–174; Dana's Min., 1874, 5th ed., 413; Roy. Soc. C. Sci. Papers, 1867, **1**, 336.

1829: 14. Berzelius. Extrait d'une lettre de M. Berzelius à M. Dulong sur la découverte d'une nouvelle terre, la Thorine. Séances de l'acad. royale des sciences. Paris, 1829, July 20.

Ann. chim. phys., 1829, **41**, 422–423; 1829, **42**, 67; L'Universel, 1829, No. 206, July 25; Bibl. Univ., 1829, **41**, 255–256; Le Globe, 1829, [7], **58**, 463, July 22; J. de pharm., 1829, **15**, 488–489; Am. J. Sci., 1830, **17**, 381; Roy. Soc. C. Sci. Papers, 1867, **1**, 336.

1829: 15. Berzelius. Thorina and Thorinium.

Bibl. Univ., 1829, **41**, 255–256; Phil. Mag., 1830, **7**, 388–389.

1829: 16. Editor's notice. Thorine, a new earth. Thorite (Brevig mineral).

Edinb. Phil. J., 1829, **20**, 363.

1829: 17. Berzelius. Entdeckung einer neuen Erde und eines neuen Metalls der Thorerde und des Thoriums.

J. für Chem. (Schweigger), 1829, **57**, 492–493.

1829: 18. Bulletin des travaux de la Société de Pharmacie de Paris. Extraits du procès verbal. Séance du 15 Août. Sur la thorine "Dulong donne lecture d'une lettre de M. Berzelius."

J. de pharm., 1829, **15**, 488–489.

1829: 19. Editorial. Atomgewichte der einfachen Körper nach Berzelius' neuesten Bestimmungen.

J. tech. Chem., 1829, **2**, 455–470.

1830: 20. Berzelius. Atomengewichte der einfachen Körper.

Pharm. Centrbl., 1830, 8–10.

1830: 21. Berzelius. Untersuchung einer minerals von Brevig, Norwegen. "Thorium," "Thorit."

Kongl. Sv. Vet. Acad. Handl., 1829, 1–30; Årsb. Phys. Kemi, 1830, 95–97; Berzelius' Jsb., 1831, **10**, 98–100.

1830: 22. Berzelius. Thorerdesalze.

Kongl. Sv. Vet. Acad. Handl, 1829, 18; Årsb. Phys. Kemi, 1830, 139; Berzelius' Jsb., 1831, **10**, 143–144.

1831: 23. Berzelius. Om Vanadin och dess egenskaper. "Vanadinsyrad Thorjord."

Kongl. Sv. Vet. Acad. Handl., 1831, 1–67; Ann. der Phys. Pogg., 1831, **22**, 1–67; Ann. chim. phys., 1831, **47**, 337–409; J. für Chem. (Schweigger), 1831, **62**, 121–124; 323–374; Berzelius, Traité de Chimie, 1831, t. **4**, 642–686; J. für Chem. (Schweigger), 1831, **63**, 26–54; Årsb. Phys. Kemi, 1831, 99–110; Berzelius' Jsb., 1832, **11**, 97–108; J. tech. chem., 1831, **1**, 141–142; Ztschr. Physik u. Mathematik, 1831, **9**, 391–392; Phil. Mag., 1831, **10**, 321–337; 1831, **11**, 7–20; Magazin für Pharm., 1831, **33**, 249–253; Roy. Soc. C. Sci. Papers, 1868, **2**, 336; 1872, 6.

1832: 24. Berzelius. Recherches sur la thorine, nouvel oxyde.

Ann. der Phys. Pogg., 1829, **16**, 385–415; Ann. Mines, 1832 [3], **1**, 98–106.

1832: 25. Berzelius. Analyse du thorite minéral contenant une nouvelle terre.

Ann. der Phys. Pogg., 1829, **16**, 385–415; Ann. Mines, 1832 [3], **1**, 183–185.

1832: 26. Berzelius. Analyses of thorite, by Berzelius.
Beudant, Min., 1832, **2**, 171–172, 741.

1832: 27. Berzelius. Mention of false discovery of Thorium (xenotime).
Beudant, Min., 1832, **2**, 552–553, 752.

1832: 28. Beudant. Un Minéral de Coromandel.
Beudant, Min , 1832, **2**, 652.

1833: 29. Wöhler. Thorerde im Pyrochlor.
Ann. der Phys. Pogg., 1833, **27**, 80; Ann. der pharm., 1833, **8**, 154; Pharm. Centrbl., 1834, 174; Rammelsberg's Min. Chem., 1875, 2d ed., 371–375; Jahrb. Min., 1833, 64, 424; Ber., 1882, **15**, 3181*a*; Roy. Soc. C. Sci. Papers, 1872, **6**, 412.

1833: 30: Berzelius. Atomgewichte der einfachen Körper.
Pharm. Centrbl., 1833, 2-3.

1833: 31. Berzelius. Undersökning af tellurens egenskaper. "Tellursyrlig thorjord."
Kongl. Sv. Vet. Acad. Handl., 1833, 227–307; Ann. der Phys. Pogg., 1833, **28**, 392–400; 1834, **32**, 1–32, 577–627; Ann. chim. phys., 1835, **58**, 113–150, 225–281; Årsb. Phys. Kemi, 1832, 103–106; 1833, 96–103; 1834, 148–152, 163–167; Berzelius' Jsb., 1833, **12**, 100–103; 1834, **13**, 94–102; 1835, **14**, 146–149, 161–164; J. de pharm, 1833, **19**, 582–587; 1836, **22**, 147–149; Phil. Mag., 1836, **8**, 84–85; Am. J. Sci., 1835, **28**, 137–140; Ann. Mines, 1834, **5**, 381–385; Roy. Soc. C. Sci. Papers, 1867, **1**, 338.

1834: 32. Berzelius. Atomgewichte der einfachen Körper.
Pharm. Centrbl., 1834, 1–2.

1835: 33. Berzelius. Om distillationsprodukterna af Drufsyra, (Acidum Paratartaricum).
Kongl. Sv. Vet. Acad. Handl., 1835, 142–169; Ann. der Phys. Pogg., 1835, **36**, 1–28; Bibl. Univ., 1836, **3**, 398–402; J. de pharm., 1835, **21**, 242–245; 1836, **22**, 138–142; Ann. der pharm., 1835, **13**, 61–63; Arsb. Phys. Kemi, 1835, 255–265; Berzelius' Jsb., 1836, **15**, 254–264; Roy. Soc. C. Sci. Papers, 1867, **1**, 338.

1835: 34. Berzelius. Atomgewichte der einfachen Körper.
Pharm. Centrbl., 1835, 1–2.

1836: 35. Berzelius. Atomgewichte der einfachen Körper.
Pharm. Centrbl., 1836, 1–2.

1837: 36. Berzelius. Atomgewichte der einfachen Körpers.
Pharm. Centrbl., 1837, 1–2.

1838: 37. Berzelius. Atomgewichte der einfachen Körpers.
Pharm. Centrbl., 1838, 1–2.

1839: 38. Rose. Ueber die mineralogische und geognostische Beschaffenheit des Ilmengebirges.

Berichte. Königl. Akad. d. Wiss. Berlin, 1839, 53–61; Ann. der Phys. Pogg., 1839, **47**, 374–384; Jahrb. Min., 1840, 709–714; Roy. Soc. C. Sci. Papers, 1879, **8**, 276.

1839: 39. Berzelius. Atomgewichte der einfachen Körper.

Pharm. Centrbl., 1839, 1–2.

1839: 40. Rose, G. Beschreibung einiger neuen Mineralien des Urals. "Tschewkinit."

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170	Gibbs, George	Comparative Vocabulary,	4to.*	20	1863	
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389	Henry, Joseph	Investigation of Illuminants,	R. 1880	25	1881	
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399	Holmgren, F.	Color-blindness,	R. 1877	72	1878	
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406	Henry, Joseph	Researches in Sound,	R. 1878	106	1879	.25
407	Gray, Asa	Memoir of Joseph Henry,	R. 1878	35	1879	
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409	Sherman, W. T., Parker, P., Baird, S. F., Cluss and Schulze	Report of Museum Building Commission and of the Architects for 1879,	R. 1879	18	1880	
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411	Lautenbach, B. F.	Irritation of Polarized Nerve,	R. 1878	59	1880	
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413	Goode, G. Brown	Berlin Fishery Exhibit. Bull. Nat. Mus., No. 18,		278	1880	
414	Schott, C. A.	Base Chart of the United States,	*	1	1880	
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416		Smithsonian Miscellaneous Collections. Vol. XIX,	M.C. xix	1034	1880	
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421	Boehmer, G. H	Index to Smithsonian Anthropological Articles,	R. 1879	10	1881	
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424		Smithsonian Miscellaneous Collections. Vol. XXI,	M.C. xxi	773	1881	
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426	Holden, E. S. & Hastings, C. S.	Synopsis of Herschel's Writings,	R. 1880	118	1881	
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431	Gill, Theo.	Recent Progress in Zoölogy,	R. 1880	62	1881	
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436	Baird, S. F.	List of Periodicals received by Smithsonian Institution,	R. 1880	9	1881	
437	Rhees, Wm. J.	Check List of Publications of Smithsonian Institution,	M.C. xxvii	22	1881	
438	Holden, E. S. & Boehmer, G. H.	Reports of Astronomical Observatories for 1880,	R. 1880	128	1881	.10
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442		Annual Report of Smithsonian Institution for 1880,	R. 1880	782	1881	
443	Caswell, A.	Meteorological Observations, Providence, 1831-1876,	S.C. xxiv	40	1882	.25
444	Ward, L. F.	Flora of Washington, D. C. Bulletin National Museum No. 22,		265	1881	
445	Goode, G.Brown	Plan of Organization and Regulations of National Museum. Circular N. M. No. 1,	M.C. xxii	58	1882	
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448	Baird, S. F.	Department of Insects. Circular N. M. No. 4,	M.C. xxii	2	1882	
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456	Hornaday, W.T.	Classification of Collections in Taxidermy. Circular N. M. No. 12,	M.C. xxii	2	1882	
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464	**Bean, T. H.**	Directions for Collecting and Preserving Fish,	M.C. XXII	6	1881	.02
465	**Rathbun, R.**	List of Marine Invertebrates. Series II,	M.C. XXII	6	1881	
466	**Rhees, Wm. J.**	Directory of Employes of Smithsonian Institution, Nat. Museum, etc.,	8vo.*	8	1882	
467		Proceedings of National Museum for 1881. Vol. IV,	M.C. XXII	600	1882	
468		Smithsonian Miscellaneous Collections. Vol. XXII,	M.C. XXII	1200	1882	
469	**Baird, S. F.**	List of Foreign Correspondents of Smithsonian Institution,	M.C. XXVI	174	1882	.10
470	**Scudder, S. H.**	Nomenclator Zoölogicus. Alphabetical List of Genera of Animals. Bull. N. M. No. 19,		74	1882	
471	**Rathbun, R.**	List of Marine Invertebrates. Series III,	M.C. XXII	4	1881	
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474	**Baird, S. F.**	List of Publications of National Museum. Circular N. M. No. 18,	M.C. XXII	12	1882	
475		Smithsonian Miscellaneous Collections. Vol. XXIII,	M.C. XXIII	1003	1882	
476	**Powell, J. W.**	First Annual Report of Bureau of Ethnology, for 1879-80,		638	1881	
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481	Mason, O. T.	Miscellaneous Anthropological Papers,	R. 1881	162	1883	
482	Gore, J. H.	Tuckahoe, or Indian Bread,	R. 1881	13	1883	.05
483	Holden, E. S.	Progress in Astronomy for 1881,	R. 1881	42	1883	.10
484	Abbe, Cleveland	Progress in Meteorology for 1881,	R. 1881	126	1883	.10
485	Barker, G. F.	Progress in Physics and Chemistry for 1881,	R. 1881	60	1883	.10
486	Farlow, W. G.	Progress in Botany for 1881,	R. 1881	20	1883	.05
487	Gill, Theo.	Progress in Zoölogy for 1881,	R. 1881	92	1883	.10
488	Mason, O. T.	Progress in Anthropology for 1881,	R. 1881	30	1883	.10
489	Cope, E. D.	Bone Cave in West Indies,	S.C. xxv	34	1883	.50
490	Boehmer, G. H.	Additions to List of Foreign Correspondents,	M.C. xxvi	56	1883	
491	Sherman, W. T. Parker, P., Baird, S. F., Cluss and Schulze	Report of Museum Building Commission and Architects,	R. 1881	10	1882	
492	Jordan, D. S., & Gilbert, C. H.	Synopsis of Fishes of North America. Bulletin N. M. No. 16,	M.C. xxiv	1074	1882	
493	Yarrow, H. C.	North American Reptilia and Batrachia. Bulletin N. M. No. 24,		255	1883	
494	Verrill, A. E. & Rathbun, R.	List of Marine Invertebrates. Series I,	*	6	1879	
495	Jones, J. M., and others	Natural History of the Bermudas. Bulletin N. M. No. 25,		377	1884	
496		Smithsonian Miscellaneous Collections. Vol. XXIV,	M.C. xxiv	1082	1883	
497		Bulletin of Philosophical Society of Washington. Vols. I, II, III,	M.C. xx	779	1881	1.00
498		Bulletin of Philosophical Society of Washington. Vol. IV,	M.C. xxv	189	1881	.25
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501		Transactions of Anthropological Society of Washington. Vol. I. (1879-1882),	M.C. xxv	142	1882	.25
502		Abstract of Transactions of Anthropological Society of Washington. Vol. I. (1880-1881),	M.C. xxv	150	1883	.25
503		Bulletin of Philosophical Soc. of Wash'n. Vol. V. (1881-1882),	M.C. xxv	189	1883	.25
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505		Smithsonian Miscellaneous Collections. Vol. XXVI,	M.C. xxvi	866	1883	
506		Smithsonian Miscellaneous Collections. Vol. XXVII,	M.C. xxvii	814	1883	
507	Le Conte, J. L., & Horn, G. H.	Classification of N. A. Coleoptera,	M.C. xxvi	606	1883	3.00
508	Goode, G. Brown	Bibliography of S. F. Baird. Bulletin National Museum. No. 20,		395	1883	
509	Rau, Charles	Prehistoric Fishing,	S.C. xxv	360	1884	2.00
510	Goode, G. Brown	Report of Assistant Director of National Museum for 1881,	R. 1881	82	1883	
511		Catalogue of London Fisheries Exhibition. Bulletin National Museum. No. 27,		1333	1884	
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513		Bulletins of National Museum. (Nos. 1-10, collected as Vol. I of Bulletins),	M.C. xiii	998	1877	
514	Bolton, H. C.	Catalogue of Scientific Periodicals (1665-1882),	M.C. xxix	783	1885	
515		Annual Report of Smithsonian Institution for 1881,	R. 1881	855	1883	
516	Tarr, R. S.	List of Marine Invertebrates. Series IV,		5	1883	
517	Yarrow, H. C.	Check List of Reptiles. Bulletin N. M. No. 24,		28	1883	.02
518		Proceedings of National Museum for 1882. Vol. V,		715	1883	

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519		Bulletins of National Museum. (Nos. 11-15, collected as Vol. II of Bulletins),	M.C. XXIII	997	1883	
520	Baird, S. F.	Report of Secretary of Smithsonian Institution for 1882,	R. 1882	58	1883	.10
521		Bulletin of National Museum. (No. 16, as Vol. III of Bulletins),	M.C. XXIV	1333	1883	
522		Smithsonian Miscellaneous Collections. Vol. XXVIII,	M.C. XXVIII	777	1887	
523		First Report of Board on Geographic Names,	*	21	1890	
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525	Holden, E. S.	Progress in Astronomy for 1882,	R. 1882	50	1883	
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543		Bulletin of Philosophical Soc. of Wash'n. Vol. VI (for 1883),	M.C. xxxiii	220	1884	.25
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548		Proceedings of National Museum for 1883. Vol. VI,		565	1884	
549	Binney, W. G.	Manual of American Land Shells. Bulletin N. M. No. 28,		528	1885	
550	Henry, Joseph	Scientific Writings. 2 vols.,	M.C. xxx	1103	1886	3.00
551	Goode, G. Brown	Catalogue London Fisheries Exhibition. Part of Bulletin N. M. No. 27,		108	1883	
552	Rathbun, R.	Catalogue of Crustaceans, etc., London Fisheries Exhibition. Part of Bulletin N. M. No. 27,		31	1883	.05
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559		Smithsonian Miscellaneous Collections. Vol. XXXI,	M.C. xxxi	990	1888	
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561	Simpson, J. H.	Coronado's March in Search of the Seven Cities of Cibola,	R. 1869	34	1884	
562	True, F. W.	Catalogue of Aquatic Mammals, London Fisheries Exhibition. Part of Bulletin N. M. No. 27,		32	1884	.10
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569	Webster, H. E.	Annelida from Bermuda. Part of Bulletin N. M. No. 25,		26	1884	
570	Scudder, N. P.	Bibliography of Isaac Lea. Bulletin Nat. Museum, No. 23,		337	1885	
571	Rhees, Wm. J.	Check List of Smithsonian Publications. December, 1881, to March, 1884,	*	7	1884	
572	Rau, C.	Circular relative to Aboriginal Antiquities. Circ. N. M. No. 21,		5	1883	
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575	Hunt, T. S.	Progress in Geology in 1883,	R. 1883	22	1884	.10
576	Green, F. M.	Progress in Geography in 1883,	R. 1883	17	1884	.05
577	Abbe, C.	Progress in Meteorology in 1883,	R. 1883	92	1884	.10
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581	Farlow, W. G.	Progress in Botany in 1883,	R. 1883	18	1884	.05
582	Gill, T.	Progress in Zoölogy in 1883,	R. 1883	53	1885	.10
583	Mason, O. T.	Progress in Anthropology in 1883,	R. 1883	43	1884	
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587	Goode, G. Brown and others	Report of the Assistant Director and Curators of the National Museum for 1883,	R. 1883	200	1885	
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590	Niblack, A. P.	Instructions for Paper Moulds of Inscriptions in Stone, etc. Circular Nat. Museum, No. 23,		5	1883	
591	Gray, Asa	Flora of N. America. Gamopetalæ,	M.C. xxxi	986	1888	
592		Bulletin of Philosophical Society. Vol. VII. for 1884,	M.C. xxxiii	195	1885	.25
593		Annual Report of the Smithsonian Institution for 1883,	R. 1883	997	1885	
594	Mills, C. K.	Mental Overwork. Toner Lecture. No. 9,	M.C. xxxiv	38	1885	
595	Taylor, W. B.	Refraction of Sound,	R. 1875	12	1885	.05
596	Howitt, A. W.	Australian Group Relations,	R. 1883	28	1885	.05
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598	Merrill, G. P.	Plan of Building Stone Exhibit. Circular Nat. Museum, No. 25,		2	1884	
599	Clarke, F. W.	Plan for Gem and Precious Stone Exhibit. Circ. N. M. No. 26,		2	1884	
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602	True, F. W.	Plan for Mammal Exhibit. Circular National Museum, No. 29,		27	1884	
603	Bendire, C. E.	Instructions for Collecting Eggs. Circular Nat. Museum, No. 30,		4	1884	
604	Dewey, S. P.	Plan for Mineral Exhibit. Circular National Museum, No. 31,		8	1884	
605	Dorsey, J. O.	Comparative Phonology of Sioux Languages,	R. 1883	11	1885	.05
606		Smithsonian Contributions to Knowledge. Vol. XXV,	S.C. xxv	508	1885	
607		Proceedings of National Museum. Vol. VII. for 1884,		669	1885	
608	Baird, S. F.	Report of Secretary of Smithsonian Institution for 1884,	R. 1884	98	1885	.10
609	Holden, E. S.	Progress in Astronomy in 1884,	R. 1884	55	1885	.10
610	Marcou, J. B.	Progress in Palæontology in 1884,	R. 1884	20	1885	.10
611	Green, F. M.	Progress in Geography in 1884,	R. 1884	19	1885	.05
612	Abbe, Cleveland & Fassig, O. L.	Progress in Meteorology in 1884,	R. 1884	176	1885	.10
613	Barker, G. F.	Progress in Physics in 1884.	R. 1884	57	1885	.10
614	Bolton, H. C	Progress in Chemistry in 1884,	R. 1884	52	1885	
615	Dana, E. S.	Progress in Mineralogy in 1884,	R. 1884	19	1885	.05
616	Rockwood, C. G., Jr.	Progress in Vulcanology and Seismology in 1883-84,	R. 1884	21	1885	.10
617	Gill, T.	Progress in Zoölogy in 1884,	R. 1884	93	1885	.10
618	Mason, O. T.	Progress in Anthropology in 1884,	R. 1884	41	1885	
619	Vreeland, C. E. & Bransford, J. F.	Antiquities at Pantaleon, Guatemala,	R. 1884	12	1885	
620		Miscellaneous Anthropological Papers,	R. 1884	38	1885	
621	Mason, O. T.	Guesde Collection of Antiquities, Guadeloupe,	R. 1884	107	1885	
622	Flint, J. M. & Beyer, H. G.	Classification of Materia Medica Collection. Circ. N. M. No. 32,		39	1885	
623		Annual Report of the Smithsonian Institution for 1884,	R. 1884	943	1885	

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624	Stejneger, L.	Ornithological Explorations in Commander Islands. Bulletin National Museum, No. 29,		382	1885	
625	Marcou, J. B.	Bibliographies of F. B. Meek, C. A. White, & C. D. Walcott. Bulletin Nat. Museum, No. 30,		333	1885	
626	Lucas, F. A.	Notes on Preparation of Skeletons. Circular Nat. Museum, No. 33,		8	1885	
627	Rhees, Wm. J.	Price List of Smithsonian Publications,	R. 1885	27	1885	
627a	Rhees, Wm. J.	Price List of Smithsonian Publications, Oct. 1, 1886,	*	26	1886	
628	Bolton, H. C.	Index to Literature of Uranium. 1789-1885,	R. 1885	36	1885	
629	Baird, S. F.	Report of the Secretary of the Smithsonian Institution for six months to June 30, 1885,	R. 1885	46	1885	.10
630		Transactions of Anthropological Society. 1883-85,	M.C. xxxiv	226	1886	.25
631	Powell, J. W.	Third Annual Report Bureau of Ethnology. 1881-82,		680	1884	
632	Goodrich, J. K.	Progress in Geography in 1885,	R. 1885	36	1886	.10
633	Bolton, H. C.	Progress in Chemistry in 1885,	R. 1885	50	1886	
634	Rockwood, C. G., Jr.	Progress in Vulcanology and Seismology in 1885,	R. 1885	23	1886	.10
635	Boehmer, G. H.	List of Foreign Correspondents to July, 1885,	R. 1885	201	1886	
636		Bulletin of Philosophical Society. Vol. VIII. 1885,	M.C. xxxiii	115	1886	.50
637	Baird, S. F.	Lending Type Specimens. Circular Nat. Museum, No. 35,		1	1886	
638	Barker, G. F.	Progress in Physics in 1885,	R. 1885	60	1886	.10
639	Dana, E. S.	Progress in Mineralogy in 1885,	R. 1885	26	1886	.05
640	Mason, O. T.	Progress in Anthropology in 1885,	R. 1885	56	1886	
641	Winlock, W. C.	Progress in Astronomy in 1885,	R. 1885	114	1886	
642	Marcou, J. B.	Progress in Palæontology in 1885,	R. 1885	47	1886	
643	Gill, Theo.	Progress in Zoölogy in 1885,	R. 1885	53	1886	.10
644	Thoroddsen, T.	Volcanic Eruptions and Earthquakes in Iceland,	R. 1885	47	1886	

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645		Miscellaneous Anthropological Papers,	R. 1885	44	1886	
646		Exchanges of Birds and Eggs. Circular N. M. No. 34,		1	1886	
647	Mitchell, S. W., & Reichert, E. T.	Venoms of Poisonous Serpents,	S.C. xxvi	196	1886	
648		Annual Report of Smithsonian Institution, Pt. 2, 1884, Museum,	M.R. 1884	468	1885	
649		Annual Report of the Smithsonian Institution, Jan. to July, 1885,	R. 1885	1014	1886	
650		Proceedings of National Museum. Vol VIII for 1885,		787	1886	
651	Baird, S. F.	Report of Secretary of Smithsonian Institution for year 1885-86,	R. 1886	83	1886	.10
652	Powell, J. W.	Fourth Annual Report of Bureau of Ethnology. 1882-83,		595	1886	
653	Williston, S.W.	Synopsis of N. A. Syrphidæ. Bulletin N. M. No. 31,		365	1886	
654		Annual Report of the Smithsonian Institution, Pt. 2, Jan. to July, 1885. Museum,	M.R. 1885	1220	1886	
655		Proceedings of National Museum. Vol. IX for 1886,		722	1887	
656	Cope, E. D.	Catalogue of Batrachians of Central America and Mexico. Bulletin Nat. Museum, No. 32,		98	1887	
657	Baird, S. F.	Report of Secretary of Smithsonian Institution for 1886-'87,	R. 1887	27	1887	.10
658	Tuckerman, A.	Index to Literature of the Spectroscope,	M.C. xxxii	433	1888	1.00
659	Clarke, F. W.	Table of Sp. Gravities. Constants of Nature, Part I. (2nd edition),	M.C. xxxii	417	1888	2.00
660		Smithsonian Miscellaneous Collections. Vol. XXXII,	M.C. xxxii	855	1888	
661		Bulletin of Philosophical Society, 1886-1887. Vols. IX & X and Index for Vols. 1 to 10,	M.C. xxxiii	376	1888	.50
662		Smithsonian Miscellaneous Collections. Vol. XXXIII,	M.C. xxxiii	910	1888	

No.	Author.	Title.	Size or Series.	Pages.	Date.	Price.
663	Traphagen. F. W.	Index to Literature of Columbium 1801-1887,	M.C. xxxiv	30	1888	.25
664	Winlock, W. C.	Bibliography of Astronomy, 1887,	M.C. xxxiv	63	1888	
665	Bolton, H. C.	Bibliography of Chemistry, 1887,	M.C. xxxiv	13	1888	
666	Boehmer, G. H.	Additions to List of Foreign Correspondents—to July, 1886,	R. 1886	36	1889	
667	Boehmer, G. H.	Systematic List of Foreign Correspondents—to July, 1886,	R. 1886	55	1889	
668	Langley, S. P.	Report of Secretary of Smithsonian Institution for 1887-'88,	R. 1888	123	1890	.10
669		Proceedings of the National Museum. Vol. X, for 1887,		779	1888	
670	Powell, J. W.	Fifth Annual Report of the Bureau of Ethnology, for 1883-1884,		617	1887	
671	Agassiz, L. and Fewkes, J. W.	Anatomy of Astrangia Danæ,	4to	20	1889	.75
672	Agassiz, L., Baird, S. F., Jordan, D. S.	Six Species of North American Fresh-water Fishes,	4to	12	1889	.75
673	Hyatt, A.	Genesis of the Arietidæ,	S.C. xxvi	278	1889	2.50
674	Egleston, T.	Cat. of Minerals. Bull. N. M. No. 33,		198	1889	
675	Boehmer, G. H.	Report on Astronomical Observatories, 1886,	R. 1886	119	1889	.10
676		Annual Report of the Smithsonian Institution for 1885-86,	R. 1886	896	1889	
677		Annual Report of the Smithsonian Institution, Pt. 2, 1885-1886, Museum,	M.R. 1886	583	1889	
678		Proceedings of the National Museum. Vol. XI, for 1888,		716	1889	
679	Cope, E. D.	Batrachia of North America. Bulletin Nat. Museum, No. 34,		525	1889	
680	Edwards, H.	Bibliography of Transformations of Lepidoptera. Bull. N. M. No. 35,		147	1889	
681	True, F. W.	Review of Delphinidæ. Bulletin National Museum, No. 36,		191	1889	

No.	Author.	Title	Size or Series.	Pages.	Date.	Price.
682	Dall, W. H.	Catalogue of Mollusks, S. E. Coast of the United States. Bulletin National Museum, No. 37,		221	1889	
683	Boehmer, G. H.	Report on Exchanges for 1886,	R. 1886	30	1889	.05
684		Miscellaneous Anthropological Papers,	R. 1886	132	1889	
685	Stearns, R. E. C.	Parasites in the Pearl Oysters,	R. 1886	6	1889	.05
686	Fleming, S.	Time Reckoning for the Twentieth Century,	R. 1886	22	1889	.05
687	Rhees, W. J.	Catalogue and Index of Smithsonian Publications, 1846-1886,	R. 1886	383	1889	
688	Kidder, J. H.	Report on International Exchanges for 1888,	R. 1888	16	1888	.05
689		Annual Report of the Smithsonian Institution for 1886-87,	R. 1887	755	1889	
690		Annual Report of the Smithsonian Institution, Pt. 2, 1886-1887, Museum,	M.R. 1887	789	1889	
691	Bigelow, F. H.	Solar Corona discussed by Spherical Harmonics,	*	22	1890	
692	Todd, D. P.	Photographs of Solar Corona, Jan. 1, 1889,	*	9	1890	
693	Powell, J. W.	Sixth Annual Report of the Bureau of Ethnology, for 1884-1885,		733	1888	
694	Boehmer, G. H.	Report on Exchanges for 1887,	R. 1887	24	1889	.05
695	Huxley, T. H.	Advance of Science in last Half Century,	R. 1887	42	1889	.05
696	Winlock, W. C.	Progress in Astronomy in 1886,	R. 1887	89	1889	
697	Darton, N. H.	Progress in Geology in 1886,	R. 1887	41	1889	.10
698	Marcou, J. B.	Bibliography of North American Palæontology, 1886,	R. 1887	57	1889	
699	Rockwood, C. G.	Progress in Vulcanology and Seismology in 1886,	R. 1887	24	1889	.10
700	Libbey, W., Jr.	Progress in Geography in 1886,	R. 1887	13	1889	.05
701	Barker, G. F.	Progress in Physics in 1886,	R. 1887	60	1889	.10
702	Bolton, H. C.	Progress in Chemistry in 1886,	R. 1887	61	1889	
703	Dana, E. S.	Progress in Mineralogy in 1886,	R. 1887	28	1889	.05

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704	Gill, Theo.	Progress in Zoölogy in 1886,	R. 1887	46	1889	.10
705	Mason, O. T.	Progress in Anthropology in 1886,	R. 1887	45	1889	
706		Miscellaneous Anthropological Papers,	R. 1887	123	1889	
707	Dana, J. D.	Memoir of Arnold Guyot,	R. 1887	30	1889	.05
708	Allen, H.	Study of the Skull. Toner Lect. X,	M.C. XXXIV	83	1890	
709	Watkins, J. E.	Report on Steam Transportation Exhibit,	M.R. 1886	23	1889	
710	Clarke, F. W.	Meteorite Collection,	M.R. 1886	11	1889	
711	Kunz, G. F.	Gem Collection,	M.R. 1886	9	1889	
712	Merrill, G. P.	Building and Ornamental Stones,	M.R. 1886	372	1889	
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714		List of Museum Accessions in 1885-1886,	M.R. 1886	109	1889	
715	Mason, O. T.	Cradles of the Amer. Aborigines,	M.R. 1887	52	1889	
716	Porter, J. H.	Artificial Deformation of Children,	M.R. 1887	23	1889	
717	Mason, O. T.	Human Beasts of Burden,	M.R. 1887	59	1889	
718	Stearns, R. E. C.	Ethno-conchology, a Study of Primitive Money,	M.R. 1887	38	1889	
719	Hornaday, W.T.	Extermination of American Bison,	M.R. 1887	184	1889	
720	Hough, W.	Preservation of Mus. Specimens,	M.R. 1887	10	1889	
721		List of Museum Accessions in 1886-87,	M.R. 1887	129	1889	
722	Langley, S. P.	Report of Secretary of Smithsonian Institution for 1888-89,	R. 1889	90	1891	.10
723	Langley, S .P.	Circular Concerning Department of Antiquities. Cir. N. M. No. 36,		6	1889	
724	Donaldson, T.	Catlin Indian Gallery,	M.R. 1885	946	1886	
725	Koehler, S. R.	Cat. of Graphic Arts Exhibit, Cincinnati, 1888. Cir. N. M. No. 37,		31	1888	
726	Watkins, J. E.	Cat. of Transportation Exhib., Cincinnati, 1888. Cir. N. M. No. 38,		18	1888	
727	Adler, Cyrus	Cat. of Oriental Antiquities, Cincinnati, 1888. Cir. N. M. No. 39,		7	1888	

No.	Author.	Title.	Size or Series.	Pages.	Date.	Price.
728	Wilson, Thos.	Prehistoric Anthropological Exhibit, Cincinnati, 1888. Cir. N. M. No. 40,		33	1888	
729	True, F. W.	Guide to Mammal Exhibit, Cincinnati, 1888. Cir. N. M. No. 41,		26	1888	
730	Wilson, Thos.	Cir. Relative to Prehistoric Anthropology. Cir. N. M. No. 42,		16	1888	
731		Smithsonian Contributions to Knowledge. Vol. XXVI,	S.C. xxvi	472	1890	
732	Mason, O. T.	Throwing-Sticks, in the National Museum,	M.R. 1884	48	1890	
733	Mason, O. T.	Basket Work of N. A. Indians,	M.R. 1884	146	1890	
734	Murdoch, John	Study of Eskimo Bows,	M.R. 1884	36	1890	
735	Goode, G.Brown	Report of Ass't Sec. June 30, 1888,	M.R. 1888	84	1890	
736	Adler, Cyrus	Report on Oriental Antiquities, 1888,	M.R. 1888	12	1890	
737	Watkins, J. E.	Report on Transportation, 1888,	M.R. 1888	5	1890	
738	Niblack, A. P.	Indians of Alaska,	M.R. 1888	160	1890	
739	Hippisley, A. E.	Cat. of Chinese Porcelains,	M.R. 1888	105	1890	
740	Lucas, F. A.	Expedition to Funk Island,	M.R. 1888	37	1890	
741	Tuckerman, A.	Index to Thermodynamics,	M.C. xxxiv	244	1890	
742	Hough, Walter	Fire-making Apparatus in Nat. Museum,	M.R. 1888	57	1890	
743	Wilson, Thos.	Prehistoric Anthropology, a handbook for beginners,	M.R. 1888	75	1890	
744		List of Museum Accessions in 1887-1888,	M.R. 1888	82	1890	
745	Rhees, W. J.	Check List Smithsonian Publications, 1846-1890,	*	35	1890	
746		Proceedings Regents; Report Exec. Com.; Acts Congress,	R. 1888	35	1890	.05
747	Winlock, W. C.	Progress in Astronomy in 1887-1888,	R. 1888	94	1890	
748	McGee, W J	Progress in Geology in 1887-1888,	R. 1888	46	1890	
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750	Merrill, G. P.	Progress in Petrography in 1887-1888,	R. 1888	30	1890	

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753	Dana, E. S.	Progress in Mineralogy in 1887-1888,	R. 1888	21	1890	.05
754	Knowlton, F. H.	Progress in Botany in 1887-1888,	R. 1888	24	1890	.10
755	Mason, O. T.	Progress in Anthropology in 1887-1888,	R. 1888	88	1890	.10
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760	Marcou, J.	Derivation of name America,	R. 1888	29	1890	
761	Adler, C.	Oriental Science in America,	R. 1888	30	1890	.10
762	Ridgway, R. Mallery, G., Taylor, W. B., Dall, W. H., Powell, J. W.	Biographical Memoirs of Spencer F. Baird,	R. 1888	44	1890	.10
763	Dana, E. S., Farlow, W. G.	Biographical Memoirs of Asa Gray,	R. 1888	83	1890	.02
764	Rogers, J. A.	Correction of Sextants,	M.C. XXXIV	36	1890	.15
765	Jouy, P. L.	Korean Mortuary Pottery,	M.R. 1888	26	1890	
766	Wilson, T.	Man in North America in Paleolithic Period,	M.R. 1888	25	1890	
767		Report of Smithsonian Institution, 1887-88,	R. 1888	880	1890	
768		Report of Smithsonian Institution, Pt. 2, 1887-88, Museum,	M.R. 1888	898	1890	
769		Report of Smithsonian Institution, 1888-89,	R. 1889	861	1890	
770		Report of Smithsonian Institution, Pt. 2, 1888-89, Museum,	M.R. 1889	951	1891	
771	Langley, S. P.	Report of Secretary of Smithsonian Institution for 1889-90.	R. 1890	94	1891	.10
772		Proceedings Regents; Report Exec. Com.; Acts of Congress,	R. 1889	38	1890	.05

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773	Guttstadt, A.	Scientific Institutions in Berlin,	R. 1889	58	1890	.10
774	De Tunzelmann, G. W., Trouton, Fred. T.	Hertz's Researches, Electric Oscillations,	R. 1889	61	1890	.10
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779		*Physical Papers:*	R. 1889	48	1890	.10
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	Lodge, O. J.	Modern Theory of Light,				
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	Anderson, Wm.	Molecular Structure of Matter,				
780	Lovering, Jos.	Michelson's Researches on Light,	R. 1889	22	1890	.05
781		*Anthropological Papers:*	R. 1889	64	1890	.25
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	Unset, I.	Scandinavian Archæology,				
	Topinard, P.	Last Steps in Genealogy of Man,				
782	Mason, O. T.	Progress in Anthropology in 1889, Bibliography of Anthropology in 1889,	R. 1889	80	1890	.10
783	Adams, H. B.	The State and Higher Education,	R. 1889	18	1890	.05
784	Scaiffe, W. B.	Geographical Latitude,	R. 1889	47	1890	.05
785	Tuckerman, A.	Bibliography of Chemical Influence of Light,	M.C. XXXIV	26	1891	.25
786	Goode, G. B.	Report of Asst. Sec'y on National Museum, 1889,	M.R. 1889	277	1891	
787	Goode, G. B.	List of American and Foreign Libraries,	M.R. 1889	89	1891	
788	Müller, A.	Memoir of H. L. Fleischer,	R. 1889	21	1890	.05
789	Wenham, F. H.	Aerial Locomotion,	R. 1889	23	1890	
790	Rhees, W. J.	Price List Smithsonian Publications, May, 1889,	*	33	1889	

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791	Helmholtz, R.	Memoir of G. R. Kirchhoff,	R. 1889	16	1890	
792	Goode, G. B.	Museums of the Future,	M.R. 1889	21	1891	
793	Thomson, W. J.	Easter Island Antiquities,	M.R. 1889	108	1891	
794	Mason, O. T.	Aboriginal Skin-dressing,	M.R. 1889	39	1891	
795	True, F. W.	The Puma,	M.R. 1889	20	1891	
796	Lucas, F. A.	Animals Threatened with Extermination,	M.R. 1889	43	1891	
797	Watkins, J. E.	Development of the American Rail,	M.R. 1889	60	1891	
798	Lucas, F. A.	Explorations in Newfoundland,	M.R. 1889	22	1891	
799	Merrill, G. P.	Hand-book of Dept. of Geology,	M.R. 1889	52	1891	
800	Gray, A.	Forest Trees of N. America, Plates (23),	*	4	1891	
801	Langley, S. P.	Experiments in Aerodynamics, 1st ed.,	S.C. xxvii	118	1891	
		Experiments in Aerodynamics, 2d ed.,	S.C. xxvii	118	1902	1.00
802		Proceedings Regents; Report Exec. Com.; Acts Congress,	R. 1890	35	1891	.05
803	Schubert, H.	Squaring the Circle,	R. 1890	26	1891	.05
804	Winlock, W. C.	Progress in Astronomy, 1889-'90.	R. 1890	64	1891	
805	Woodward, R.S.	Mathematical Theories of the Earth,	R. 1890	20	1891	.05
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814	Thompson, S.P.	Koenig's Researches on Musical Harmony,	R. 1890	27	1891	.05

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825	Montelius, O.	Age of Bronze in Egypt,	R. 1890	30	1891	.05
826	Mason, O. T.	Progress in Anthropology in 1890, Bibliography of Anthropology in 1890,	R. 1890	84	1891	.10
827	Snyder, J. F.	Primitive Urn Burial,	R. 1890	7	1891	.05
828	Allen, G. A.	Manners and Customs of the Mohaves,	R. 1890	4	1891	.02
829	Wilson, T.	Criminal Anthropology,	R. 1890	72	1891	.10
830	Carter, R. B.	Color-vision and Color-blindness,	R. 1890	20	1891	.05
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832	Watkins, J. E.	Ramsden Dividing Engine,	R. 1890	21	1891	.05
833	Newton, H. A.	Memoir of Elias Loomis,	R. 1890	32	1891	.05
834		Memoir of W. K. Parker,	R. 1890	6	1891	.05
835	Rhees, Wm. J.	List of Smithsonian Publications, Jan., 1892,	*	27	1892	
836	Langley, S. P.	Report of Secretary Smithsonian Institution for 1890-91,	R. 1891	65	1893	.10
837		Report of Smithsonian Institution. 1889-90.	R. 1890	849	1891	
838	Haupt, P.	Report on Congress of Orientalists. Sept., 1889,	R. 1890	10	1891	
839		Smithsonian Contributions to Knowledge. Vol. XXVII,	S.C. XXVII			

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846		Report of Smithsonian Institution. Pt. 2. 1889-90. Museum,	M.R. 1890	829	1891	
847	Powell, J. W.	Seventh Report Bureau of Ethnology, 1885-86,		452	1891	
848		Report Smithsonian Institution for 1890-'91,	R. 1891	758	1893	
849		Smithsonian Miscellaneous Collections. Vol. XXXIV,	M.C. XXXIV	1069	1893	
850	Bolton, H. C.	Bibliography of Chemistry, 1492-1892,	M.C. XXXVI	1225	1893	3.50
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855	Powell, J. W.	Eighth Report Bureau of Ethnology. 1886-1887,		334	1891	
856	Sherborn, C. D.	Index Foraminifera. Part I,	M.C. XXXVII	243	1893	1.00
857	Powell, J. W.	Ninth Report Bureau of Ethnology. 1887-1888,		663	1892	
858		Proceedings Regents; Report Exec. Com.; Acts Congress,	R. 1891	37	1893	.05
859	Huggins, W.	Celestial Spectroscopy,	R. 1891	36	1893	.10
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967		Report Smithsonian Institution, Pt. 2, 1892-93, Museum,	M.R. 1893	815	1895	
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1080	Powell, J. W.	Fourteenth Report of Bureau of Ethnology for 1892-93. Part II,		497	1897	
1081		List of Foreign Correspondents of Smithsonian Institution, 1897,		340	1897	.50
1082	Langley, S. P.	Memorial of G. Brown Goode,	*	30	1897	.02
1083	Powell, J. W.	Fifteenth Report of Bureau Ethnology for 1893-94,		487	1897	
1084	Howe, J. L.	Bibliography of Platinum metals,	M.C. XXXVIII	318	1897	.75
1085	Powell, J. W.	Sixteenth Report of Bureau American Ethnology for 1894-95,		445	1897	
1086	Goode, G. B.	History, first Half-Century of the Smithsonian Institution, 1846-96,	*	866	1897	12.50
1087	Holden, E. S.	Earthquakes on Pacific coast,	M.C. XXXVII	257	1898	.50
1088	Langley, S. P.	Report of Secretary, Smithsonian Institution for 1896-97,	R. 1897	82	1898	.10
1089		Report of Smithsonian Institution, Pt. 2, 1894-95. Museum,	M.R. 1895	1100	1897	

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1090	Mathews, J. A.	Bibliography of metallic carbides,	M.C. XXXVIII	32	1898	.25
1091	Rhees, W. J.	List of Smithsonian publications, April, 1898,	*	29	1898	
1092		Smithsonian Miscellaneous Collections. Vol. XXXIX,	M.C. XXXIX	831	1899	
1093		Smithsonian Miscellaneous Collections. Vol. XL,	M.C. XL	1259	1898	
1094		Proceedings of Regents: Executive Com., Acts Congress, etc., 1896,	R. 1896	43	1898	.05
1095	Newcomb, S.	Problems of Astronomy,	R. 1896	12	1898	.02
1096	Koenigsberger, L.	Helmholtz principles, Mathematics and Mechanics,	R. 1896	34	1898	.05
1097	Cornu, A.	Phenomena of the Upper atmosphere,	R. 1896	11	1898	.02
1098	Dewar, J.	Researches on Liquid air,	R. 1896	16	1898	.02
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1100	Wiener, O.	Color photography,	R. 1896	41	1898	.02
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1104	Thomson, J. P.	Physical Geography of Australia,	R. 1896	30	1898	.02
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1106	Thurston, R.H.	Animal as a prime-mover,	R. 1896	44	1898	.02
1107	Foster, M.	Advances in Medicine, Surgery, etc.,	R. 1896	28	1898	.02
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1110	Murray, J.	Marine organisms,	R. 1896	15	1898	.02
1111	Heim, Dr.	Relations between Plants and Ants,	R. 1896	47	1898	.05
1112	Gill, Theo.	Questions of Nomenclature,	R. 1896	29	1898	.02
1113	Schweinitz, E. A. de	War with Microbes,	R. 1896	14	1898	.02
1114	Roberts-Austen, W. C.	Rarer metals,	R. 1896	21	1898	.02

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1121	Rhees, W. J.	Memoir of William Bower Taylor,	R. 1896	14	1898	.02
1122	Woodward, H. B.	Memoir of Joseph Prestwich,	R. 1896	12	1898	.02
1123	Maspero, G.	Memoir of Henry Brugsch,	R. 1896	8	1898	.02
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1127		Proceedings of Regents: Executive Committee, Acts Congress, etc.,	R. 1897	39	1898	.05
1128	Newcomb, S.	Aspects of American Astronomy,	R. 1897	17	1898	.02
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1168		Report of Smithsonian Institution, Pt. 2, 1896-97. Museum, Pt. I,	M.R. 1897	1048	1899	
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1176		Report of Smithsonian Institution for 1897-98,	R. 1898	768	1899	
1177		Report of Smithsonian Institution, Pt. 2, 1896-97. Museum, Pt. II (Goode Memorial),	M.R. 1897	527	1901	
1178	Langley, S. P.	Report of Secretary Smithsonian Institution for 1898-99,	R. 1899	89	1901	.10
1179	Powell, J. W.	Seventeenth Report Bureau American Ethnology, 1895-96. Pt. I,		561	1898	
1180	Powell, J. W.	Seventeenth Report Bureau American Ethnology, 1895-96. Part II,		283	1898	
1181		Proceedings Regents: Report Executive Com., Acts of Congress, 1898,	R. 1898	47	1900	.05
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1220	Powell, J. W.	Eighteenth Report, Bureau of Am. Ethnology for 1896-97. Part II,		478	1899	
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		Annals of Astrophysical Observatory. Vol. I. 2d ed.,		273	1902	
		The same as Senate Document No. 20, 57th Congress, 1st Session,		341	1902	† 1.65
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1311	**Langley, S. P.**	Report of Secretary, Smithsonian Institution for 1900-01,	R. 1901	145	1901	.10
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AND ITS ALLIES

BY

AMADEUS W. GRABAU

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PHYLOGENY OF FUSUS AND ITS ALLIES.*

By AMADEUS W. GRABAU.

INTRODUCTION.

The phylogeny of Gastropoda has received but little attention from students of Mollusca, who have either confined themselves to the study of faunas, and to specific description, or have investigated problems in connection with the ontogeny of individual members of one or more phyletic series. Besides the classical memoir of Hyatt, on the Tertiary species of *Planorbis* at Steinheim, only two other important works which are devoted to a study of the serial development of phyletic groups have come to my notice. These are Koken's "Entwickelung der Gastropoden vom Cambrium bis zur Trias," and an elaborate paper by the countess Maria von Linden, in which she traces the development of several genera of recent gastropoda including *Conus, Voluta* and *Strombus*. Both authors make use of the successive types of ornamentation of the shell, and Countess von Linden uses furthermore the successive changes in the color pattern of the shell as a means of establishing phyletic relationships.

The shells of Gastropoda are particularly well adapted for phylogenetic study, since all the stages from protoconch to the last stage in the development of the individual are not only retained (provided the specimen is perfect), but all of them are usually visible, so that the study of the spire furnishes us with the means of differentiating the successive stages in the development of any individual, which may then be correlated with the adult stages of more primitive types of the same phyletic series. It is a noteworthy fact that the chief changes in the gastropod shell are at the periphery and on the shoulder of the whorl, or, in other words, in those portions which are nearly always exposed even after the addition of new whorls. It is thus usually unnecessary to break down the shell, so as to get at the earlier stages, as must be done with close-coiled cephalopod shells, when young material is not available. Thus a single perfect gastropod shell will reveal in its superficial characters nearly the whole life history of the series to which it belongs.

In determining genetic boundaries, the most important shell feature is the protoconch. The genus should represent a phyletic series, in

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which all the members (species and varieties) are descended from each other or from a common ancestor within the genus. From a study of the Fusidæ it appears that the early stages of the shell, *i. e.*, the protoconch and nepionic stages of the conch, are of the greatest importance in this group, as giving evidences of genetic relationship. Parallelism constantly crops out in gastropods, where it appears to be more frequent than in any other group of mollusks. But parallelism is no guide to affinity, and hence grave mistakes in classification are made, unless this fact is borne in mind. Parallelism is much more patent in the later stages of development than in the earlier ones, although it is by no means unknown in these latter.

Two species of gastropods in which the adult characters are similar, but the early characters dissimilar, are undoubtedly less closely related than species in which the early stages are similar or identical, and the later stages diverse. A good example of this is found in the so-called species of *Fusus* which are found in the Eocene deposits of the Gulf states. These appear to be typical Fusi as far as the adult form is concerned. Even the early stages (*i. e.*, the nepionic and neanic) are in some cases not unlike those of true Fusi. But the protoconch in one group is like that of *Levifusus* or *Pleurotoma* (*Falsifusus*), and in another group it is like that of *Fulgur,* the nepionic stages in this latter case also being Fulguroid (*Fulgurofusus*). It is obvious that, in spite of the similarity of adult characteristics, these species can not be referred to *Fusus,* since the protoconch indicates that they belong to distinct phyletic series, which are more closely related to other genera than they are to *Fusus* (see pl. XVII, figs. 5–9, pl. XVIII, fig. 1).

One of the most striking examples of error in classification from want of consideration of the early stages of development is found in the recent genus *Cyrtulus,* which by all later authors is united with the Eocene genus *Clavilithes, Cyrtulus* being made a synonym. The adult features of the only known species of *Cyrtulus* are almost precisely like those of *Clavilithes parisiensis* (Mayer-Eymer), the type of the genus *Clavilithes.* This is due to the fact that both species belong to phylogerontic series in which gerontism is expressed in the manner most characteristic of gastropods; namely, in the loss of ornamentation as well as the loss of the characteristic form, the successive whorls becoming wrapped about the preceding one in such a manner as to obliterate the original outlines, except those of the spire (see figs. 13 and 14, p. 97). This is a manner of growth eminently characteristic of *Melongena,* and it may well be denominated a Melongenoid type of growth. Such a manner of growth appears in the terminal members of a great many phyletic series of gastropods, and the uniting of all such phylogerontic terminals into a single genus or even family, as

is often done, is an ignoring of the principles of genetic classification. Such fusion of terminals of distinct phyletic branches is responsible for the fact that our largest genera, such as *Fusus, Murex, Pleurotoma* and others are overrun with species of wholly foreign ancestry.

It must, however, be emphasized that the protoconch is not to be alone relied upon for the determination of generic boundaries. A gastropod shell with a Fusoid protoconch is not necessarily a *Fusus,* for it may have passed beyond the *Fusus* stage, as in *Cyrtulus,* or be a lateral branch, as in *Aptyxis, Rhopalithes,* or *Hemifusus.* The form and other characters of the adult shell must not differ too widely from those of typical Fusi. An example of similarity of protoconch and early whorls between two distinct, though perhaps related, genera, which is to be explained as a case of parallelism, is found in *Clavilithes,* and certain species of *Turbinella* of the American Eocene, as noted below.

No principles have thrown such light on the relationship of members within a phyletic group, and on the method of their development, as the law of acceleration announciated by Hyatt and Cope, and the complementary law of retardation of Cope. By an application of these laws to genetic classification, many complex problems are solved, and light is thrown on the relations of the varieties and species to each other, and their position in the phyletic series.

Modification through acceleration in development may be considered as acting in two ways: first, by condensation, and, second, by elimination of stages. Condensation of stages usually precedes elimination of stages; the stage in question occupying less and less space in the development of the individual and finally disappearing altogether. Elimination may, however, occur without previous condensation; such abrupt dropping of stages indicating a high degree of acceleration. All stages may be equally condensed or some may suffer condensation more than others. Again, condensation may affect only certain structural characters of the shell, while others suffer little or no condensation. Thus in certain species of *Clavilithes* the shelfless suture is condensed; making room for the characteristic shelf, while some of the other characters, such as the round whorl and spirals, still persist. In other words, some of the later acquired, more specialized characteristics are pushed back into earlier stages, occurring side by side with characters of a more primitive type.

The protoconch stage in the Fusidæ appears to be the least affected of all the stages by the modifying forces. Condensation appears to a less extent in this stage than in any other. In fact, in some of the specialized Fusidæ an elongation of the protoconch is a marked feature. On the other hand, the protoconch of *Fusus* is generally ornamented by characters which in a more primitive type are found only in the

conch. Thus acceleration is indicated in the protoconch of the Fusidæ by a pushing back and appearance upon its whorls of features normally characteristic of the earliest or nepionic stage of the conch.

The degree of acceleration is indicated in the successive members of a group, by the age at which distinctive features appear or disappear. Such features are of different types in different groups, but they may be classed under form and ornamentation of the whorls. In general, the more accelerated a fusoid shell is, the earlier the change from rounded to angular whorls is accomplished, and the sooner intercalated spirals make their appearance. This is progressive acceleration. In regressive types, acceleration is indicated by the early disappearance of ribs, of the peripheral angulation, and finally of the spirals.

The spirals or revolving striæ are of especial significance, as indicative of the degree of acceleration which the individual has attained. They may be divided into two groups, primary and post-primary. The first group makes its appearance more or less abruptly, especially in *Fusus*, where three or four spirals suddenly appear at the beginning of the nepionic stage. In other gastropods, these spirals may begin as a single one, increasing by the appearance of new ones on either side. This method of increase may be designated as exogenous, the new spirals appearing *outside* of the older ones; that is, between the sutures and the spiral next to it.* The second group has an endogenous manner of growth, the new spirals always becoming intercalated *between* the older ones. Secondary spirals appear between the primary ones, and tertiary between the primary and secondary. Sometimes spirals of a fourth or fifth and even of a higher cycle appear. From the method of appearance in the individual shell we can formulate the general law that species of a group in which primary spirals alone exist, are more primitive than those in which spirals of a higher cycle occur; and that in general, the higher the cycle of intercalated spirals, the more specialized or accelerated has the individual become.

Another feature by which we can measure the degree of acceleration is the posterior canal, and the accompanying subsutural band or, in some cases, the sutural shelf or terrace. The posterior canal is of the nature of a notch, at the point where the outer lip joins the body-whorl. This notch, weakly or not at all developed in the adult of primitive species, appears earlier and earlier in the successively accelerated types, and becomes more and more pronounced in the adult.

* It must be borne in mind that only below the upper suture on any whorl can we see the true edge of the shell, except on the body whorl. New spirals will therefore be seen next to the upper suture only, as we trace their development in an adult shell, while the new spirals which appear on the lower border of the whorl —*i. e.*, what was once the spindle of the body-whorl—are covered up by the succeeding whorls except in the case of the very last one.

In extremely accelerated or specialized types, such as *Clavilithes* and *Cyrtulus,* the posterior canal is so strong and broad that instead of the simple revolving subsutural band, which marks its existence in the whorls of more primitive species, a broad and pronounced sutural shelf appears. In certain gastropods, though rarely, if ever, in *Fusus,* the posterior canal becomes separated from the body-whorl, which results in the formation of a pronounced sutural canal like that of *Sycotypus canaliculatus* and other species.

The long anterior canal of the Fusidæ which is the continuation of the aperture into the spindle and the columellar portion of the spindle are usually of a fairly constant type in this group, the modifications being mainly in the length and the relative slenderness as well as in the straightness of this portion of the shell. Spirals of several cycles are almost always found on the spindle. In some phylogerontic types, and in certain old-age individuals, the inner lip becomes separated from the columella of the spindle and a slit-like umbilication is produced.

The Fusidæ as a group are highly accelerated, and near the acme of development. Primitive types are uncommon, except in the Eocene, and even there regressive species appear. The majority of species have attained the acme of development for the group, many of them reaching it while still young. This group is therefore uncommonly well supplied with phylogerontic types, and there is scarcely a specific or varietal series which does not have its degraded forms. *Fusus colus,* the type of the genus, is itself a regressively accelerated type, in which the characteristic acmatic features have nearly disappeared in the adult. Excessive degradational acceleration is seen in *Cyrtulus, Clavilithes* and similar genera.

In the present paper, the following genera of Fusoid shells are described: *Fusus, Aptyxis, Falsifusus, Fulgurofusus, Heilprinia, Euthriofusus, Cyrtulus, Clavellofusus, Clavilithes, Rhopalithes,* and *Cosmolithes.* I have studied all available species of these genera and I believe that with few exceptions they have been referred to their approximate positions in their respective phyletic series. Of the above genera, *Fusus* and *Clavilithes* are the only ones generally recognized, the species of the others being referred to one or the other of these two, or to Fasciolaria. *Cyrtulus* and *Aptyxis* have been restored to their original generic rank. *Euthriofusus* has recently been proposed by Cossman for *Fusus burdigalensis.* The other genera are new. Of the numerous species generally referred to *Fusus,* considerably less than one third actually belong to that genus, and most of these are described below. Other species, of which good illustrations have been published, are also noted, while a number of other species not here included, will on close study undoubtedly prove congeneric

with *Fusus*. No new genera are here proposed for species eliminated from *Fusus*, with few exceptions, though this will be necessary for a large proportion of them.

No researches in the phylogeny of invertebrates, as revealed by the hard parts, can be carried on at the present time without a recognition of the monumental work accomplished in this department by the late lamented Professor Alpheus Hyatt. His researches have paved the way for future investigators, and none can work in this field without acknowledging themselves his pupils. The writer has had the great good fortune to carry on a part of his investigations under circumstances which admitted of ready discussion, with Professor Hyatt, of many important points, and the cordial interest and attention which Professor Hyatt gave to this work are among the many pleasant memories associated with that best of teachers and friends. In Professor R. T. Jackson, of Harvard University, the writer has had a constant adviser, critic, and helpful sympathizer, and his invaluable aid in these directions are gladly and freely acknowledged. The writer is also indebted to Professor Jackson for assistance in the supply of material for study, as well as for many other courtesies.

The work, begun in 1898, was carried on in the Palæontological laboratory of Harvard University, and in various museums. Foremost among the latter is the Museum of Comparative Zoölogy at Cambridge, Mass.* The writer is greatly indebted to Dr. W. M. McWoodworth, assistant in charge of the Museum, for permission to study the fine series of Tertiary Fusidæ especially from European localities, which are contained in that museum, and which in extent and importance are second to none in this country. To Dr. Walter Faxon, curator of the department of recent mollusca, in the same museum, thanks and acknowledgements are due, for opportunity to study the extensive series of recent Fusidæ under his charge, as well as for many courtesies shown during the prosecution of the studies. The use of the collection of the Boston Society of Natural History† was granted by Professor Hyatt the curator. The writed spent two weeks in Washington, studying the collections at the Smithsonian Institution, and he wishes to make grateful acknowledgements of the numerous kindnesses shown him by Dr. W. H. Dall, the curator of the department of molluscs, and by the members of his staff. From Mr. Chas. T. Simpson and Dr. T. W. Vaughan the writer received many courtesies and much assistance. Through the kindness of Dr. Dall we have been enabled to figure the protoconchs of *Falsifusus meyeri* and *Heilprinia caloosaensis*.

At the Johns Hopkins University in Baltimore, the writer was given the opportunity to examine the Tertiary Fusoid shells in the

* Referred to as M. C. Z. in citation of localities, etc.

† Referred to as B. S. in the citation of localities, etc.

collection of that institution, and to Professor W. B. Clark and Dr. George C. Martin acknowledgments are hereby made.

At Philadelphia the writer was granted every opportunity to study the extensive collections of recent and fossil Fusidæ at the Academy of Natural Sciences, and the Wagner Free Institute of Science. To the officers of these institutions, particularly to Professor H. A. Pilsbry, and to Dr. Chas. W. Johnson acknowledgments and thanks are herewith tendered. To the Academy we are also indebted for the loan of specimens from which many of the illustrations of plates XVII and XVIII are made. To the Wagner Free Institute we are indebted for the loan of the original drawings of figs. 11 and 12. The original drawings of figs. 4, 9, 10, and 17 were loaned by Professor G. D. Harris, of Cornell University. The free use of the collections of the American Museum of Natural History were granted by Professor R. P. Whitfield and Dr. L. P. Gratacap, curators respectively of palæontology and of recent mollusca, and to these gentlemen thanks are due. The collections of the palæontological department of Columbia University also contain a valuable series of recent and Tertiary Fusidæ. Other acknowledgements are due to the Buffalo Society of Natural Sciences, the Massachusetts Institute of Technology and to many friends for the loan of specimens. To Miss Elvira Wood, of Washington, formerly Instructor in Palæontology in the Massachusetts Institute of Technology, the writer is greatly indebted for the care and skillful labor she has bestowed on the difficult figures of the protoconchs and early conch stages shown in plates XVII and XVIII, as well as the original figures in the text.

DESCRIPTION OF GENERA AND SPECIES, WITH A DISCUSSION OF THEIR GENETIC RELATIONSHIPS.

A.

The Genus **FUSUS** Bruguiere.

The genus *Fusus* is credited by Fisher and Cossmann to Klein (1753); by Agassiz and Scudder to Bruguiere (1791), and by Tryon and others to Lamarck (1799). Chemnitz in 1780 and later applied the name to the description of his species without however characterizing it generically. Bruguiere in 1791, in the *Encyclopedie Methodique* described the genus, including in it those species of the Linnæan genus *Murex*, which have a fusoid form. Lamarck restricted the genus by retaining in it only those shells, which were characterized by a fusoid or spindle-shaped form, a long canal, an absence of varices, and an absence of columellar plaits. Schumacher in 1817 and Swainson in 1840 still further restricted the genus, the former naming as the

type species, the *Murex colus* of Linné. Later authors have generally tended to greater restriction of the genus, by elimination of non-characteristic species, though some have attempted to extend again the meaning of the term.

In all the characterization of the genus, the form has been considered as of paramount importance. While it is true that no species which have not a true fusoid form can be relegated to this genus, it is also true that numerous species have a fusoid form which are not genetically related to *Fusus,* and hence can not be placed in that genus. The only true guide to relationship in this as in all cases, must be found in the development of the individual, *i. e.,* its ontogeny, and its relation to that of the members of its group, *i. e.,* its phyletic relation. For this purpose the earliest whorls and particularly the protoconch are of the greatest import, and no species which does not show a protoconch similar to that of *Fusus colus,* the type of the genus, can be relegated to *Fusus.* On the other hand, there are species of gastropods (*Hemifusus, Rhopalithes,* etc.) which have a *Fusus* protoconch, thus evidencing an unmistakable relationship to *Fusus,* but their form forbids that they be included under this genus. Thus the genus becomes still more restricted, and very many, perhaps most, of the species which Lamarck and some subsequent authors included in it must be removed to other genera.

The Protoconch of Fusus.

The protoconch of *Fusus* is distinctive, and has been observed in the following twenty-one recent and Tertiary species:

F. porrectus,	*F. colus,*	*F. novæ-hollandiæ,*
F. aciculatus,	*F. tuberculatus,*	*F. longirostris,*
F. acuminatus,	*F. distans,*	*F. marmoratus,*
F. asper,	*F. closter,*	*F. brasiliensis,*
F. henckeni,	*F. dupetit-thouarsii,*	*F. rostratus,*
F. cucosmius,	*F. irregularis,*	*F. bredæ,*
F. turriculus,	*F. ambustus,*	*F. carinatus.*

The protoconch is seldom preserved in recent shells. This is chiefly due to carelessness of collectors, who do not protect the apices of the shells properly, and to the deplorable habit which many collectors have of treating their shells with acids, thus destroying the finer characters of the apex. In spite of this unfavorable condition of most collections, the protoconch has been seen in so many individuals of the above-named species that no doubt exists in my mind of its relative constancy of form and characters.

The protoconch generally consists of one and a half volutions, but may be somewhat shorter or longer. No case has been observed in which the protoconch consists of as few as one volution, and only one

(*F. longirostris*) in which it consists of as many as two volutions.* The first whorl is smooth, obliquely erect, and rather prominent, the apical end convex and large. The diameter just below the apex is but slightly less than that at the end of the first volution. The enlargement of the remaining portion of the protoconch is also very slight, the shell thus having the appearance of having a swollen or apical whorl. The last half of the protoconch is marked by fine vertical riblets, which are either closely crowded or separated by interspaces having from two to three times the width of the riblets. In rare cases are the interspaces, and still more rarely the riblets marked by visible revolving lines or "spirals," though such lines of excessive tenuity and visible only in the young shell may be present.

The protoconch generally ends abruptly with a varyx, which sometimes is a riblet scarcely more prominent than the other riblets on the protoconch, or again is a strong rounded vertical ridge, two or three times the width of the normal riblets of the protoconch. The ornamentation of the nepionic shell begins abruptly, commonly in the form of spirals and rounded vertical ribs.

These peculiarities of the protoconch of *Fusus* stamp this genus as a remarkably accelerated type. Ordinarily in gastropods no ornamentation is shown on the protoconch, though *Fusus* is by no means the only one in which it occurs. Some of the other genera with ornamented protoconch will be mentioned below, but so far as my observations extend, the number of genera with such markedly differentiated protoconchs is comparatively few. In *Falsifusus* and in many species commonly referred to *Latirus, Pleurotomaria* and other related genera, the apical end is highly ornamented in the later stages, but this ornamented portion merges into what is clearly a portion of the shell itself. It is therefore somewhat doubtful whether the ornamented subapical whorls of these shells are a part of the protoconch or whether they represent a part of the nepionic shell. The same is true of other shells, in which the ornamented portion immediately succeeding the smooth portion may represent the nepionic shell instead of the protoconch. In *Fusus,* however, the protoconch ends abruptly, there being a sharp line of demarkation between the two, and the junction is furthermore accentuated by the development in most cases, of a distinct varix. Similar characteristics occur in *Hemifusus,* the ribbed portion of the protoconch being in this genus extended, so as to complete two volutions.†

* The term volution is employed throughout this paper to denote a complete revolution of the shell, the beginning and termination of the volution being in the same line, the one above the other. The term whorl is used in a less precise manner, being employed as it usually is in conchology.

† Grabau, Am. Nat., vol. XXXVI, p. 921, fig. 5.

We know so far of only a few genera which show greater acceleration in the protoconch than is shown by *Fusus*. One of these is the Fasciolarioid genus *Heilprinia,* of which *Fusus caloosœnsis* Heilprin, is the type. In this the ornamentation extends to within a very short distance of the apex, which is minute. (Plate XVIII, fig. 5.) In this genus, however, no definite line is drawn between protoconch and conch. *Falsifusus* (?) *apicalis* has another remarkably accelerated protoconch which, unlike that of *Heilprinia,* terminates abruptly. The apex of this species, however, is smooth as in the typical members of the genus *Falsifusus* (see pl. XVIII, fig. 2).

The Conch of Fusus.

In all the normal species of *Fusus* the nepionic shell is at first round-whorled, round-ribbed, and furnished with simple uniform revolving striæ or spirals. In a few highly accelerated species, this type of nepionic whorl is crowded out, its place being taken by a later angular-whorled type. Nearly always, however, in such cases, the characteristic round whorl is indicated in that portion of the conch immediately succeeding the protoconch, even though it may, and often does comprise only the merest fraction of a volution.

The angulation of the whorls is brought about by the relative excessive growth of one or more of the central spirals of the whorls. At first the three central ones are about equally strong and they may retain this subequality for a number of volutions. Sometimes the lower spiral is covered by the upper edge of the succeeding volution, in which case the appearance of a bicarinate central portion is given. A true bicarination is due to the suppression of one of the three central spirals, in favor of the other two (*Fusus dupetit-thouarsii*). Eventually, however, in nearly all cases, the multicarinate aspect gives way to a unicarinate one, in which one spiral, usually the central one, becomes stronger than the others. In *Fusus torcumus,* and some other species, however, the multicarinate feature is retained in the adult. The ribs coincidently fade away towards the sutures; they remain strong only on the angulation where they commonly give rise to nodulations, which may be rounded or vertically flattened in various degrees, even to pointedness. This condition may continue to the end, or it may become further modified by the total disappearance of the ribs, and with them the nodules. Finally the angulation disappears, the whorl thus again becoming rounded, though now without ribs. The ribs occasionally reappear in the final stages. The spirals remain simple only in the most primitive species; in all others they are fortified by intercalations at a varying age, according to the species, of secondary spirals. Often tertiary and higher series occur. Occasionally in certain species a strong spiral may become reinforced, by the appearance of fine revolving lines on its side.

In all typical species the last whorl is abruptly contracted below, and continued in a long spindle which is excavated into a long and slender anterior canal, the forward prolongation of the aperture. The columellar lip is always smooth but liræ are common on the interior of the outer lip.

In old individuals, or phylogerontic species, a more or less strong posterior canal is formed, which is the result of the upreaching of the upper portion of the last whorl onto the preceding whorl. Externally this canal is indicated by a vertical, subsutural revolving band, the occurrence of which may generally be taken as an indication of acceleration in development.

The species of *Fusus* are generally but little colored, though the apical portion and the spindle are often uniformly brown. Dark chestnut-colored spots are frequently seen between the tubercles on the periphery of the volution, and these fade out upward and downward. A periostracum, with rather strong bristles at the intersection of spirals and growth lines, covers the shell when fresh.

Type: Murex colus Linné.

Range: Eocene to present.

Distribution: Nearly all tropical and subtropical seas.

1. EOCENE SPECIES OF FUSUS.

A. Species of the London and Hampshire Basins.

FUSUS PORRECTUS (Solander).

(Plate I, figs. 5, 11, 12.)

1766. *Murex porrectus* Solander, Foss. Hants. (Brander), p. 21, pl. 11, fig. 36.
1818. *Fusus rugosus* Sowerby (non Lamarck), Min. Conch., vol. III, pl. 274, figs. 8 and 9.

The original description and illustration of this species leaves some doubt as to the exact characters of the species, which can only be settled by reference to the type specimen. However, the shells here identified with this species have characters which separate them from the British representatives of *F. aciculatus,* its nearest allies.

The protoconch of this species is obliquely erect, with the apex invested by the second whorl (fig. 1). It is smooth for about a volution and a third, after which it is ornamented by rather distant smooth vertical riblets, which extend from suture to suture. The protoconch terminates abruptly after something over a volution and a half. The ribs and spirals of the conch appear as abruptly. The whorls are rounded and separated by deeply impressed sutures which give the whorls the appearance of resting loosely one upon the other. The ribs are rounded and strongly cancellated by the spirals, of which there are four or five at the beginning of the conch. This is the most

primitive condition yet obtained in the conch of a true *Fusus*. In the succeeding stages of development, the shells of this species are scarcely modified. Several additional spirals appear between the upper suture and the spiral next to it. One of the central spirals is slightly strengthened in the adult stage is some specimens, suggesting a central carination. This incipient carination is scarcely noticeable in the majority of specimens which are referable to this species. The interspaces between this central spiral and that on either side of it are broader than those between other spirals. On the body-whorl of a large specimen (Pl. I, fig. 11) there are three uniform and equidistant spirals on either side of the central one. Above the upper set of three spirals, next to the suture, two additional new spirals have appeared. Below the three lower spirals occurs a broad interspace, and below that the spirals of the spindle. These are very oblique, diverge strongly and are early supplemented by secondary spirals, intercalated between the primary ones. In the preceding whorls, the first or uppermost of the spirals of the spindle appears just below the suture of the overlying whorls. The costæ become flattened on top in the adult. They are strong and slightly narrower than the interspaces separating them. The strengthened median spiral is not always in the center of the whorl. Frequently it is somewhat above the center, indicating that increase in breadth of whorl with continued growth was less on the suture side than on the side of the spindle.

FIG. 1. *F. porrectus*, showing protoconch and early conch whorls. Enlarged × 10. (M. C. Z. 1402.)

In accelerated individuals of this species intercalated spirals appear occasionally. These arise in the broader interspace above the spirals of the spindle, and thus appear on the lower part of the body-whorl. A specimen from Hampshire, 62 mm. long, has the intercalated spirals in the penultimate whorl.

In some of the specimens from Hampshire, there are only two spirals on the body of the whorl, below the central carinated one; a condition eminently characteristic of *F. asper* Sowerby. These may represent transitional forms.

Localities: Barton Cliff (M. C. Z. 1402); Hordle Cliff, London clay (M. C. Z. 1400); Barton Beds, Hampshire (Stud. Pal. Coll. Harv. Univ. 120).

Horizon: London Clay, Barton Beds.

This species is among the most primitive of the genus yet discovered. It retains the normal nepionic characters of the genus throughout life with scarcely any modifications.

FUSUS ACICULATUS Lamarck.

(Plate I, figs. 3 and 4; connecting form pl. I, fig. 6.)

1818. *Fusus aciculatus* LAM'K, SOWERBY, Mineral Conchology, vol. III.

This species is typically developed in the Paris Basin only. In the British Eocene, however, occur individuals which approach this species very closely, and which are generally identified with it. A complete series of specimens may be selected, connecting *F. porrectus* with typical *F. aciculatus,* showing their close genetic relation. As the young *F. aciculatus* has the characters of *F. porrectus,* is is evident that the former is a descendant of the latter. The perfect gradation in characters which is to be expected in a complete series has led some authors to unite the two species. As will be shown later, the Parisian specimens are distinguishable from their British allies by their more pronounced ornamentation. Whether we call these distinct species, or merely varieties, is of no moment, as long as we recognize the difference between the two and the different degrees of development each has attained. By retaining the distinct names, we are able readily to demarkate the various steps in the evolution of this particular group.

A similar series of connecting specimens between the British representative of *Fusus aciculatus* and *Fusus asper* may be found, though the characteristics of the latter are always very pronounced.

The following are the characteristics of the British representatives of this species:

The protoconch is smooth and obliquely elevated in the first volution, the second having strong smooth vertical riblets. It ends abruptly with a slight varix.

The conch is characterized in its nepionic stage by the normal round whorl with rounded strong vertical ribs, separated by interspaces which are wider than the ribs. They are ornamented by revolving lines or spirals, which are well marked on the ribs but produce no tubercles or spines. This primitive character continues with scarcely any modifications through the succeeding stages of the conch in *F. porrectus,* which thus exemplifies a degree of development in which the adult shell has not passed beyond the normal characteristics of the nepionic stage of the genus.

In the specimens which lead to the present species, however, a slight modification which is clearly an advance, judging from the normal order of development in more highly differentiated species, occurs in the adult stage. This consists of a slight strengthening of the central spiral, which dimly suggests a carination such as is characteristic of most species of the genus. The spirals are commonly uniform and equidistant, except near the upper suture, where new ones make their appearance, which are of course at first thinner and nearer

together. When one of the spirals becomes stronger on the center of the whorl, it generally leaves three, rarely four, and more rarely still two spirals on the shoulder above it. Assuming that the strengthened spiral is in all cases the same one in the same species (presumably the first spiral to appear, if we could trace them back to their beginning), the suggestion presents itself that those shells of the same species, in which only two spirals lie between the strengthened spiral and the suture in the adult individual are more primitive than those in which three appear, and both are more primitive than those in which four appear. This is suggested by the fact that in the shell with four spirals above the carina (*i. e.,* the central stronger spiral) in the adult, there are only three in an earlier stage, above this same spiral, whether strengthened or not, and in a still earlier stage only two. If we go back far enough, only a single spiral would probably appear between that which is strengthened later on, and the upper suture.

The shoulder above the strengthened spiral or carina is always convex in this species, and never becomes flattened or in any other way accentuated, except by the appearance of the carina. The ribs extend uniformly from suture to suture, diminishing but slightly as they approach the upper one.

Another modification of the primitive type on specimens which are included within the species is found in the accentuation of the spirals upon the ribs, thus producing a subnodose or subspinulose intersection. This is a feature eminently characteristic of specimens of this species in the Paris Basin, from which the type of Lamarck was derived. It also suggests the British *F. asper,* in which this feature is strongly developed.

Below the center of the whorl, and just below the suture, is a broader interspace than elsewhere on most adult specimens of this species. This space, lying between two primary spirals, has in a few of the more accelerated individuals an intercalated secondary spiral in the ephebic stage. This feature might occur in an unaccelerated but extremely long lived and vigorous individual, after the normal adult stage is passed. In a single specimen intercalated spirals have been observed on other parts of the whorls, but these intercalations disappear again, before the shell has reached the adult stage.

Localities: Barton cliff (M. C. Z. 1401, 1403); Hordle cliff (M. C. Z. 1407, 27737); London clay, no loc. (M. C. Z. 1406); Muddiford Harts (M. C. Z. 27736).

Horizon: Eocene.

Two shells from Muddiford Harts are the most accelerated individuals of this species which have come to my notice. They have four and five spirals respectively on the shoulder above the carina, while the more advanced of the two has two intercalated spirals in the broad

interspiral space on the under side of the whorl, which is generally free from spirals.

FUSUS ACUMINATUS Sowerby.

(Plate I, figs, 1, 2.)

1766. *Murex porrectus* SOLANDER (pars.), Foss. Hants., fig. 36.
1821. *Fusus acuminatus* SOWERBY, Min. Conch., vol. IV, p. 131, pl. 274.
1821. *Fusus aciculatus* SOWERBY, Min. Conch., vol. IV, corrigenda.

This name deserves to be revived for the species originally described under it by Sowerby. His description on page 131 of his Mineral Conchology fits well the specimens here figured and described under this name. Solander's *Murex porrectus,* fig. 36, in Brander's Fossilia Hantsoniensis which is cited by Sowerby as an example of this species, is a good illustration. In the corrigenda to volume IV of the Mineral Conchology *F. acuminatus* is made a synonym of *F. aciculatus* and as such it has since been generally regarded. Deshayes figures a Parisian specimen as a typical *F. aciculatus,* a form very different from that described by Sowerby and figured by Solander. Sowerby's species represents what appears to be a phylogerontic type, while the typical *F. aciculatus* is a progressive type, both, however, tracing their ancestry to the British *F. porrectus.*

The only specimen preserving any trace of the protoconch, in the collections examined, was imperfect; but the last portion remains (fig. 2), showing all the features found in the preceding species. The termination is abrupt, and the nepionic shell begins as abruptly. The spirals, seven of which appear on the nepionic whorl, are strong, sharp and separated by wide interspaces. They appear particularly marked on account of the faint development of the ribs. These are nearly obsolete, occurring mainly as faint wrinkles or wavings on the whorls, though on some of the neanic whorls they are moderately prominent.

FIG. 2. *Fusus acuminatus.* The protoconch of fig. 2, pl. I. The total absence of ribs on the shell is only apparent and due to the position in which the specimen was drawn, *i. e.,* to the direction of the light. (M. C. Z. 1409.)

The whorls of the conch are uniformly rounded, and rather loosely joined, leaving a deeply impressed suture. This feature is characteristic of the primitive *F. porrectus.* There is even an incipient canaliculation along the suture, which in some cases does not proceed beyond a flattening which can be traced backward to a number of whorls, becoming gradually obsolete. This flattening does not occur in the young.

This species is either primitive or phylogerontic. The loose coiling and simple spirals (without intercalations) indicate the former

state, while the absence of ribs indicates the latter. It is hardly expectable that there should be a *Fusus* primitive enough to be without ribs, for with the highly accelerated ribbed protoconch characteristic of this genus, we should assume that the most primitive *Fusus* conch is ribbed. Therefore, since ribs disappear in the old age of most Fusi it is most proper to consider this species as a descendant of the ribbed *F. porrectus,* but one in which the ribs have been almost entirely suppressed. The loose coiling is not inconsistent with the gerontic state, while the simple spirals may indicate that the series of which this species constitutes the phylogerontic terminal, is a primitive one.

Locality: Barton cliff, coll. Duval. (M. C. Z. 1408, 1409).

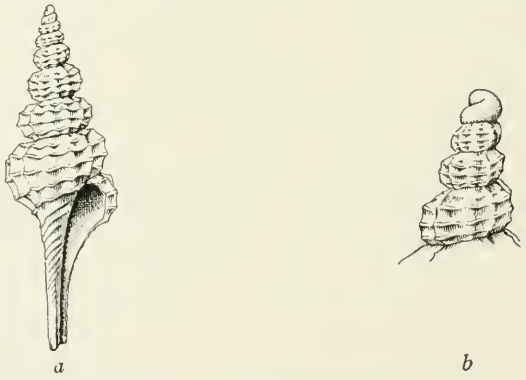
Horizon: Eocene, London clay.

FUSUS ASPER Sowerby.

(Plate I, figs. 7 and 8.)

1821. *Fusus asper* SOWERBY, Mineral Conchology, vol. 3, p. 131, pl. 274, figs. 4–7.

The protoconch is of the normal type, smooth in its early stages, and with vertical closely crowded riblets in the last half volution. The conch has nearly all the whorls angulated and ornamented with strong spirals. In the young shell two central spirals are stronger than others. Above these, on the flattened shoulder, are two striæ, and below them,



a *b*

FIG. 3, *a, b. Fusus asper. a,* a specimen enlarged ($\times \frac{5}{3}$); *b,* the protoconch and early whorls still more enlarged ($\times \frac{20}{3}$). M. C. Z. 1406.

just above the succeeding whorl, is another spiral which during the later stages becomes nearly as strong as those above it. In these later stages the three spirals are the most prominent on the shell. Where the spirals cross the ribs, flattened asperations or nodulations are produced, which are especially strongly marked in the adult stage. This species is derived from the British varieties of *F. aciculatus,* the strong ribs of *F. asper* being incipiently developed in that form. The small number of spirals on the shoulder and the simple character of these

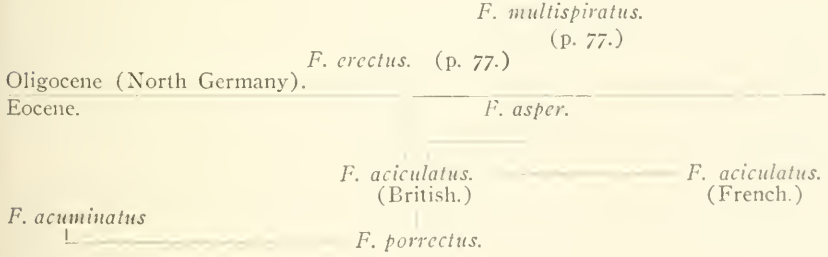
spirals indicates that its immediate ancestor was of a primitive type, and it must be regarded as a lateral branch from *F. aciculatus*. The only advance, then, which this species has made over others is in the subangulation of the whorls, and the strong development of the spirals.

Localities: London Clay, no loc. (M. C. Z. 27733); Barton cliff, (M. C. Z. 27738); Muddiford Harts (M. C. Z. 1404); London Clay, Barton (M. C. Z. 1403, 27741); Barton Beds, Hampshire (M. C. Z. 27735).

Horizon: Barton clay, Upper Eocene. London Clay (?), Lower Eocene.

Relations of the British Species of Fusus.

Considering *Fusus porrectus* nearest the primitive radicle, we may place it at the base of the series of British Fusæ. *F. aciculatus* is its natural successor, though the former species seems to have continued and to have been coexistent with the latter. *F. acuminatus* represents a lateral branch from the *F. porrectus* line, in which senile characters developed, resulting mainly in the obsolescense of ribs and the formation of a canaliculate suture. *F. asper,* on the other hand, must be considered a lateral branch from *F. aciculatus,* although this species in its accelerated individuals has in some respects become more specialized than *F. asper.* These relations may be expressed as follows:



Fusus in the Paris Basin.

FUSUS ACICULATUS Lamarck.

(Plate I, figs. 13, 15.)

1822. *Fusus aciculatus* Lamarck.

1824. *Fusus aciculatus* Deshayes, Coq. Foss. Env. Paris, T. II, p. 514, pl. 71, figs. 7, 8.

1889. *Fusus porrectus* Cossmann, Cat. Coq. Foss. Env. Paris, T. IV, p. 181.

There is only one typical representative of the genus *Fusus* in the Eocene beds of the Paris Basin. This is *Fusus aciculatus* Lamarck.

The protoconch and earliest whorls of the conch are similar to those of the British species. In the neanic and ephebic stages the Parisian variety shows some marked differences from the normal English variety. These differences are mainly of the nature of an

advance in development, due to acceleration in the evolution of the Parisian over the British individuals. The ribs of the whorls are narrow, accentuated, but rounded on top, and separated by interspaces which are several times as wide as the ribs. The spirals are strong and sharp, producing a series of asperations on the ribs which recall *F. asper,* but are less marked than in that species. The carinate aspect of the whorl is about as strongly marked as in the British species. Three spirals are characteristic of the shoulder. The space between the spirals of the body whorl and those of the spindle is generally furnished with an intercalated spiral in the later whorls. These intercalated spirals appear early in some specimens and not until the last whorl in others, showing different degrees of acceleration.

In the larger specimens the ribs often become obsolete on the last whorl and the carina is also suppressed. These features are gerontic, and not individual, but mark a general decadence of this branch of the genus. Normally this variety shows a distinct advance over the English variety, as it is characterized by the accentuation and earlier appearance of all the progressive features of the species, which in the British variety appeared late in the ontogeny and were never strongly developed. On the other hand, further advance through continued accentuation of the progressive features appears to have been prevented by the peculiar conditions which existed in the Paris Basin; and in common with other species of the family, *F. aciculatus* assumed gerontic characteristics.

Localities: Paris (M. C. Z. 1411, 1412); Parnes (M. C. Z. 1410).

Horizon: Eocene, Calcaire Grossier of the Paris Basin.

This species appears to be a local modification of the variety characterizing the British Eocene. While we must thus postulate a connection between the British and the French Eocene Basins, permitting species to migrate from one to the other, the individual characters of the species in the two areas show that the connection was not such as to allow free intercommunication.

2. THE FUSUS COLUS SERIES.

This series comprises the typical Fusi, including the type species, *Fusus colus* Lamarck. The species of this series are characterized by the possession of a long slender spire and a similarly slender and elongated spindle. *Fusus colus* occupies a somewhat advanced position in the series, possessing some of the features characteristic of the terminal members of the series. This group of Fusi has its earliest representation in the Miocene (?) of the Antillean region, but no

species have as yet been recorded from the Old World Tertiary. Modern representatives are found in the Antillean waters of the New World, but they are not very common. The series is, however, well represented in the Indo-Pacific seas where most of the living species occur.

Tertiary Species.

FUSUS HENEKENI Sowerby.

1850. *Fusus henekeni* Sowerby, Quart. Journ. Geol. Soc., vol. 6, p. 49.
1876. *Fusus henekeni* Sowerby, Guppy, Quart. Journ. Geol. Soc., vol. 32, p. 524, pl. 28, fig. 6.
Not *Fusus henekeni* Gabb, Journ. Acad. Nat. Sci. Phil., 2d ser., vol. 8, p. 350, pl. 45, fig. 31.

The protoconch of this species is typically fusoid, though somewhat more depressed than that of most species. It consists of one and one half volutions, the last half or two third volution being furnished with numerous smooth, narrow and closely crowded vertical ribs. The protoconch ends abruptly, though no strong varix occurs, while the ornamentation of the conch begins as abruptly. The whorls of the conch embrace rather closely; they are round and are furnished with round, broad and thick ribs, which are separated by narrower interspaces. Strong, nearly uniform spirals encircle the shell, the three peripheral ones being somewhat more pronounced than the others. Above these occurs another spiral, and below them two additional ones. The spirals remain simple as far as the sixth or seventh whorl, when intercalated spirals appear. In the later whorls the lines of growth are lamellose, producing a strongly cancellated appearance.

The whole aspect of this shell, as well as its more detailed characteristics, recall forcibly the recent species *F. turriculus* from Chinese waters, and *F. cucosmius* from the Caribbean sea. Its most marked distinction lies in the closer embracing whorls, which give the shell a somewhat shorter and stouter aspect; and in the stouter ribs which give it a somewhat more rude aspect. On the whole, it must be confessed that very little difference exists between the recent and the Tertiary species from the same region.

In one specimen in the collection of the Philadelphia Academy the intercalated spirals do not appear until the tenth or last whorl, the ribs at the same time becoming obsolete. Other specimens with obsolete ribs on the last whorl have been observed. This feature, showing individual senescence, also occurs in the recent species.

Localities: San Domingo (Phil. Acad. Sci.); Jamaica (Phil. Acad. Sci.).

Horizon: Bowden beds of the Upper Oligocene or Chipolan stage (Dall—Table Tert. Hor. N. Am., p. 340).

FUSUS HAITENSIS Sowerby.

1850. *Fusus haitensis* SOWERBY, Quart. Journ. Geol. Soc., vol. 6, p. 49.
1876. *Fusus henekeni* var. *haitensis* GUPPY, Quart. Journ. Geol. Soc., vol. 32, p. 524, pl. 28, fig. 2.

This species is like the preceding except that the last two whorls show a flattening of the shoulder and a peripheral angulation. The ribs also become obsolescent towards the sutures, but remain strong on the periphery, thus producing a crude nodulation. The last two whorls are also somewhat more drawn out, so as to expose more of the preceding whorl. Intercalation begins early. In the specimens examined the apex was imperfect, and intercalated spirals were present on the earliest whorl preserved.

In the specimen figured by Guppy at least four angular whorls occur; the ribs continue to the last whorls, though prominent only on the periphery. The keel is sharp and strongly developed, the shoulder flat, and the spirals compound. The shell is a parallel to *F. torcumus* in the *F. colus* series.

This species is an accelerated *F. henekeni,* but with constant characteristics, which show that this is not a case of individual gerontism. It is rather phyletic, and hence of specific value. From this it appears that this species is not to be united with the preceding one, as has been done by Guppy, Gabb and others.

Locality: San Domingo (Phil. Acad. Sci.).

Horizon: Upper Oligocene (occurring with the preceding).

RECENT SPECIES.

FUSUS EUCOSMIUS Dall.

1889. *Fusus eucosmius* DALL, Blake Moll., p. 167, pl. 35, fig. 5.

This species is more compact and shorter than the Chinese *F. turricula,* which it resembles closely. The protoconch has a more compact appearance, the ribs in the latter portion being somewhat stronger than those in *F. turriculus.* The protoconch ends in a strong varix. Intercalation begins on the fifth or sixth whorl. The three central spirals generally become prominent in the young shell, sometimes as early as the second or third whorl. The middle one of the three is always the strongest. A slight flattening of the shoulder accompanies the strengthening of the central spirals, this feature being most marked in the adult. The shoulder spirals do not increase in strength in the same proportion that the central ones do, and hence there is a marked difference between these two sets in the adult. In the adult the ribs are generally more bulging than is the case in *F. turriculus.* The aperture is often strongly contracted, and a sudden enlargement like a strong varix has been observed in some specimens.

With the typical form occurs a variety which approaches much more closely to *F. turriculus* than does the species. In fact, the two might be considered identical if found in the same waters. This variety has the typical fusoid protoconch, with narrow riblets on the last two-third whorl. It is slightly more condensed than the Chinese species, not so much through greater embracing of the whorls, but through a greater vertical compression of the whorls, which makes them appear more swollen at the middle. The spirals have the same sharp character where they cross the ribs, but they remain simple somewhat longer, intercalated spirals appearing only in the last whorl, and then not becoming very prominent. The ribs are much less prominent than in the species proper, and they are always more than their width apart, becoming still further separated in the last whorl.

This variety compares best with immature *F. turriculus*, in which the whorls and ribs have not yet become swollen.

Localities: Off Key West, U. S. Fish Comm. station 2316, 50 fms. on coral, temp. 74 degr. 2 spec. (U. S. Nat. Mus. 93647); between Tampa and Dry Tortugas, U. S. Fish Comm. Sta. 2411, 27 fms. (U. S. Nat. Mus. 93649); off Key west U. S. Fish Comm. Sta. 2317, 45 fms. (U. S. Nat. Mus. 83511); off Key West, Sta. 2318, 45 fms. on coral, temp. 75 degrees (U. S. Nat. Mus. 93648).

Variety: Between Miss. Delta, and Cedar Keys, Sta. 2402, in mud, 111 fms. 2 specimens (U. S. Nat. Mus. 93650); Gulf stream, Stimpson dredge (M. C. Z. 962), 1 spec.

FUSUS TURRICULUS Kiener.

(Plate II, fig. 1; Plate XVII, fig. 1.)

1842. *Fusus turricula* Kiener, Iconographie, p. 6, pl. V, fig. 1.
1847. *Fusus turricula* Kiener, Reeve, Iconica, pl. 6, fig. 23.

The protoconch of this species represents the typical *Fusus* protoconch. The whole protoconch comprises about one and one half volutions, of which the first is smooth, and the other half furnished with faint crowded, vertical riblets, which become stronger towards the end. A strong, smooth varix marks the end of the protoconch.

The conch begins abruptly, with rounded whorls, rounded ribs, at first somewhat fainter than the terminal varix of the protoconch, and rounded revolving spirals, which produce a strong sculpturing on the ribs. The spirals become stronger, but remain simple for the first two volutions of the conch. Then intercalations begin, at first on the lower part of the whorl, and then farther up. The intercalations become compound by the sixth volution of the conch, the striæ near the center at the same time becoming sharper on the ribs, and the latter less strongly outlined. In some specimens an incipient flattening appears on the shoulder and with this usually appears a slight peripheral

angulation. In such accelerated individuals the upper one of the three central spirals increases in strength, and the space above produces the flattened shoulder. The ribs become obsolete towards the sutures but remain swollen on the periphery, thus giving the angulation a resemblance to a subspinose carina. Such a subangulation is not infrequently followed by a return to a normal round-whorled condition, when the ribs assume again their normal characteristics.

Sometimes specimens occur which retain a more primitive form of whorl and spiral, the latter remaining uniform throughout, though with intercalations, while the whorls retain their rounded outline. Individual senescence is marked by the obsolescence of the ribs of the last whorl, and by the separation of the inner lip from the columella.

The whorls of normal specimens of this species embrace only the spindle of the whorl preceding, thus exposing as much of the whorl above the lower as below the upper suture. This gives to the whorls the appearance of resting the one upon the other, and gives the shell a particularly graceful outline. In some aberrant individuals however (*F. chinensis?*) the whorls embrace more, giving the shell a stouter aspect. This leads to such species as *F. reeveanus* Phill.

Localities: China sea (M. C. Z. 915, 916, 917, 918, 33); China sea (U. S. Nat. Mus. 18380-b, 91747); Manila, Stearns coll. (U. S. Nat. Mus. 91748); China sea (Phil. Acad. Sci.).

A magnificent specimen eight inches long, in the Haines collection of the American Museum of Natural History, shows the normal gerontic characteristics of this species. The specimen is from the China seas.

About five normal volutions occur, with simple spirals and the form and contour of whorls and ribs usual in this species. These are followed by six volutions of the same type, but with additional spirals intercalated between the primary ones. At the end of this, the eleventh whorl, the size of the shell and all its characteristics are those of the normal individuals of *F. turriculus.* The secondary spirals have attained the size of the primary ones, and tertiary spirals make their appearance.

The last two whorls are free from ribs, except at the beginning, where faint indications occur. The whorls are uniformly rounded, and have all the characters of those of *F. nobilis,* to which this species is a parallel. It is, however, much more slender than *F. nobilis.* It will be observed that a larger number of young whorls are marked with simple spirals than is the case in *F. turriculus* ordinarily. As far as the early stages are concerned, then, this individual is more retarded in development than the normal. The long life of the individual was favorable to the development of normal regressive characteristics; no indications of progressive characters, such as the incipient angulation

of the whorls found in some normal individuals, and leading to *F. turcumus,* have been observed.

FUSUS REEVEANUS Philippi.

1847. *Fusus multicarinatus* Reeve, Iconica, pl. 6, fig. 22.
1851. *Fusus reevcanus* Philippi, Abbildungen, vol. III, p. 119.

No authentic specimens of this species have been seen, though some specimens in the U. S. Nat. Museum may belong here. The species was first figured by Reeve, as *F. multicarinatus* Lam. Kiener, however, figured a wholly distinct shell as Lamarck's type of *F. multicarinatus.* Sowerby refigures Reeve's shell under Lamarck's name, adding that "Kiener's shell has angular whorls, while Lamarck's has 'tours tres-arrondies.'" Tryon adopts Kiener's figure as the type of Lamarck's species. Philippi apparently agrees with Kiener. Tryon makes the present species a variety of *F. spectrum* Adams and Reeve. It is, however, distinct, and Philippi's name must stand.

This species represents the stout mutation of *F. turriculus,* being connected with that species by the stouter varieties of the same (*F. chinensis?*). Sowerby says that the difference between this species and *F. turriculus* lies "in the greater prominence of the plaits and whorls and the deeper excavation of the suture" in the latter species. It seems proper to call this species a lateral branch from the *F. turriculus* stock, developed under conditions which enforced upon the shell a greater degree of compactness and solidity during growth.

Habitat: Unknown.

FUSUS NOBILIS Reeve.

1847. *Fusus nobilis* Reeve, Iconica, Fusus sp. 60.

A magnificent specimen of this species occurs in the Haines collection of the American Museum of Natural History. It is almost identical with Reeve's figure 60, in shape and size. It is the *turriculus* type but in a condensed form. Its ribbed stages agree completely with Reeve's figure of *F. reevcanus,* to which the present species holds the same relation as the large gerontic type previously described holds to *F. turriculus. F. nobilis* is an extremely accelerated type, intercalated spirals appearing in the youngest whorls preserved (third or fourth). There are about nine ribbed whorls of the *reevcanus* type. In the seventh whorl tertiary spirals appear, which in the ninth become compound, having divided into two or sometimes more.

Locality: Philippines.

FUSUS SPECTRUM Adams and Reeve.

1848. *Fusus spectrum* Adams and Reeve, Voyage Samarang.
1848. *Fusus spectrum* Reeve, Iconica, pl. 18, sp. 68.

No specimens of this species have been seen, but from the figure given by Reeve it appears to be an accelerated species of the *F. tur-*

riculus type. The preëphebic characters appear to be those of an adult *F. turriculus,* while the ephebic characters consist chiefly in a strongly developed keel, which is at first nodulated, but appears to lose these nodes on the latter portion of the last whorl. If this diagnosis is correct we have here another lateral branch from the *F. turriculus* stock, in which the angulation, developed to a slight degree in many specimens of *F. turriculus,* becomes a permanent adult characteristic of specific value.

Habitat: Eastern seas (Adams and Reeve).

FUSUS TOREUMUS Martyn.

(Plate II, fig. 7.)

1784. Martyn, Univ. Conch., t. 56.
1843. *Fusus toreuma* Lamarck, Anim. sans Vert. (Desh. edit.), vol. IX, p. 444.
1847. *Fusus toreuma* Reeve, Iconica, sp. 27.

This species begins with a well-developed *turriculus* stage, in which the whorls are round, furnished with strong rounded ribs and ornamented by strong and regular spirals. In a specimen in the Boston Society of Natural History collection there are seven round *turriculus* whorls, before the angulation begins. Usually the specimens of this species are more accelerated, which is shown by the fact that the *turriculus* stage is restricted to a few only of the apical whorls. In the specimen mentioned intercalated spirals appear in the fifth whorl, or before the angulation. Usually they arise with the angulation, which in the majority of cases is in the fifth or sixth whorl. The angulation is generally caused by the strengthening of two spirals, thus producing a bicarinate aspect. When only one spiral is strengthened in the beginning, this may be supplemented by subsequent strengthening of an adjoining spiral, either above or below. Sometimes both upper and lower spirals are strengthened, thus producing a tricarination. Not infrequently, however, in the adult one of the spirals (typically the central one) surpasses the others in strength, thus giving to the tubercles a sharp aspect instead of the blunt appearance produced by the equal development of two or more spirals.

With the appearance of the angulation the shoulder becomes gradually depressed, until it has become quite flat or even somewhat concave. Simultaneously with the flattening of the shoulder the ribs become obsolete towards the suture, and finally are represented only by the tubercles, a strong development of which is characteristic of the species.

Old age is shown in this species either by a return to the normal round-ribbed condition, a clear case of atavism, or by a gradual loss of the tubercles, and the production of a round ribless whorl. In this latter case a slight carination generally precedes the complete loss of

adult characteristics. Accompanying this is a loosening of the inner lip, which often becomes quite separated from the columella. A strong posterior canal is also frequently developed by an encroachment of the final portion of the last whorl on that preceding it.

This species and *F. tuberculatus* have many characters in common, indeed there are intermediate individuals connecting them. Nevertheless they are distinct species, representing the same stage of development in species apparently belonging to separate series. That they are genetically related can not be doubted, in fact they may be regarded as representing the two series at the point of divergence. The slender character of this shell, its smaller angle of divergence and the somewhat greater obliquity of the whorls distinguish this species from *F. tuberculatus* and at once suggest its relation to *F. colus*. The coloration of the present species consists chiefly in dark brown spots in the intertubercular spaces, these occasionally appearing in the spaces between the ribs, on the *turriculus* stage.

Localities: East Indies (M. C. Z. 937, B. S. 219 and 262, Nat. Mus. 7378, 36720 and 36718); Ceylon (Nat. Mus. 91741, 131157); Pacific islands (Nat. Mus. 18379, Phil. Acad.?); Mauritius (M. C. Z. 884); Tongatabue (Nat. Mus. 7378) (Nat. Mus. 2713).

FUSUS COLUS (Linné).

(Plate II, figs. 8–11.)

1767. *Murex colus* Linné, Syst. Nat. ed., 12, p. 1221.
1817. *Fusus colus* Schumacher, Essai d'un nouveau syst. d. habit. des vers Testacés.
1842. *Fusus colus* Kiener, Iconographie, pl. IV, fig. 1.
1847. *Fusus colus* Lamarck, Hist. An. sans Vert. (Desh. Ed.), p. 443.
1847. *Fusus colus* Reeve, Iconica, sp. 11.

The protoconch of this species has been observed in only one specimen, all the others being imperfect. In that specimen it partakes of the brown color of the other apical whorls, but is perfectly smooth for the first volution. The remaining half volution of the protoconch is ornamented by fine smooth vertical riblets, about fifteen in number. The protoconch ends abruptly with a strong varix.

The conch begins with a *turriculus* stage, consisting of six or seven whorls which are round and furnished with regular rounded and spirally sculptured ribs. In rare cases there are more than seven *turriculus* whorls. Intercalated spirals appear in the fourth or fifth volution, or in general before the completion of the *turriculus* stage.

The second stage in the development of the conch is the *torcumus* stage, in which the characters are those of an adult *F. torcumus*. This stage appears gradually, being heralded by the appearance of a peripheral angulation, which, becoming more and more pronounced, finally

merges into a strong tuberculated keel. As in *F. torcumus,* the ribs become fainter and fainter away from the periphery, until finally the keel alone is characterized by them. Even in the coloring the *F. torcumus* character is maintained, this consisting of brown spots in the inter-tubercular spaces. This is also true in general of the *turriculus* stage, in which the brown color is confined to the spaces between the ribs.

The *torcumus* stage covers usually from three to four volutions, after which the tubercles become obsolete, and finally disappear. There remains then finally a smooth keel, more or less strongly marked in the center of the whorl, and giving it a subangular appearance. This may be regarded as the *colus* stage; but in a typical *F. colus,* all three stages, viz., the *turriculus, torcumus* and *colus* stages are present. There may be a greater or less development of one or the other, according to individual acceleration or retardation, but none is absent. The occurrence of these three stages clearly establishes the ancestry of this species, and marshals into proper array the other species of this series.

In many cases a fourth stage occurs, in which the keel becomes suppressed, a smooth rounded whorl remaining. This is the *longicaudus* stage, and marks the early stages of gerontism in this species. The appearance of this stage does not make a *F. longicaudus* of this species, since in the typical members of that species the *torcumus* stage is suppressed. It is simply a case of individual acceleration, so that normal gerontic characteristics appear in the ephebic stage of an otherwise normal *F. colus.*

The *colus* stage—a well-developed median keel—may occupy only a portion of a volution, or it may extend over a volution and a half. The *longicaudus* stage seldom occupies more than a small part of a volution. Two specimens from the Indian ocean (M. C. Z. 32) show pronounced variations. One is accelerated, showing angulation and intercalated spirals on the second or third volution, and a keeled (*colus*) stage covering over a volution and a half. This is succeeded by the keelless (*longicaudus*) stage, covering a fraction of a volution. The earlier stages being shortened, room is made for the introduction of additional stages at the end. This is not to be regarded as individual senescence, but as a case of acceleration in development, there being nothing in the character of the shell to indicate that the individual was not perfectly vigorous. (Plate II, fig. 8.)

The other specimen is an example of a retarded individual. It has five shouldered and tuberculated whorls following the *turriculus* stage. There is no *colus* stage, the tubercles persisting to the end (Plate II, fig. 9).

According to the definition of our species, this specimen should be classed with *F. torcumus,* never passing beyond the *torcumus* stage. It

has, however, the general aspect of a *F. colus,* being larger than the average *F. torcumus.* The specimen furthermore suggests having been derived from a *F. colus* rather than *F. torcumus,* and that therefore it is retarded in development and not primitive. This can perhaps not be proven, but as stated the whole appearance of the shell suggests it.

It will thus be seen that a young *F. colus* or a retarded one have the characteristics of an adult *F. torcumus,* and that though a young individual may perhaps be placed under its proper species, the position of a retarded individual must be determined by the standard of individual opinion.

Another individual (M. Z. 904 not figured) shows the same retarded characteristics. In this, the first seven or eight whorls are in the *turriculus* stage, intercalated spirals appearing in the last two of these. The next whorl is transitional, and the two following are typical tuberculated *torcumus* whorls. The last whorl has the tubercles less compressed vertically; these therefore have a more rounded or knobbed appearance. This gives them a resemblance to those of a normal *F. tuberosus,* which, however, belongs to a distinct series.

This individual is certainly not a typical *F. colus,* neither can it be classed with typical *F. torcumus.* It is better classed as a retarded and abnormal variety of the former.

A specimen from Amboyna (B. S. 6078 not figured) has eight *turriculus* whorls, four *torcumus* whorls and one *colus* whorl, this latter towards the end merging into a keelless *longicaudus* stage. The number of angular *torcumus* whorls is sometimes as high as six. It is not uncommon for the angular tubercled whorls to extend nearly to the end, the *colus* stage being restricted to a portion of the last whorl. Such shells, though similar to, are yet distinguishable from gerontic individuals of *F. torcumus.* In all these varieties the inner lip is always more or less strongly lirate.

The following stages then, may be distinguished in typical *Fusus colus:*

Protoconch	*a,* smooth.
	b, ribbed.
Nepionic	*turriculus* stage.
Neanic	*torcumus* stage.
Ephebic	*colus* stage.
Gerontic or paraephebic in accelerated individuals	*longicaudus* stage.

Localities: East Indies (M. C. Z. 936, 904?, B. S. 219); Philippines (M. C. Z. 902); Indian Ocean (M. C. Z. 32); Amboyna: Maluccas, (B. S. 6078); Ceylon (Reeve).

FUSUS LONGICAUDUS Bory, var. TOREUMOIDES var. nov.

(Plate II, figs. 2 and 3.)

Fusus colus and *F. longicauda* in part, of authors.

This variety is intermediate between *F. colus* and *F. longicaudus*. It differs from the normal *F. colus* in having the *torcumus* stage weakly developed or almost suppressed, while the *longicaudus* stage is well developed. It differs from *F. longicaudus* in not having the *torcumus* stage wholly suppressed. The *torcumus* stage is not so much condensed, as it is weakly developed over the extent of several whorls. The *colus* stage is generally well developed, though often obscured by the strengthening of other spirals. In a specimen from Ceylon (M. C. Z. 883) the tubercles are continuous nearly to the end, but throughout they are faint, more as in the latter portion of *F. colus*. The last whorl assumes the *colus-longicaudus* characteristics.

Sometimes the ribs reappear after they have disappeared, thus showing reversion to an earlier characteristic.

A specimen of unknown locality (M. C. Z. 908) belongs here. The first whorl or two are broken away, and of the remaining, seven are round with round ribs and uniform spirals. Intercalated spirals appear in the latter of these. On the succeeding whorls the ribs become faint and practically disappear. A keel is gradually developed through the strengthening of the lower of the two central spirals. The third central spiral also becomes strong, giving the appearance of bicarination. From temporary reappearance of ribs the keel at times becomes nodulose.

Localities: Ceylon (M. C. Z. 883) ; no loc. (M. C. Z. 905, 908).

FUSUS LONGICAUDUS Bory.

(Plate II, figs. 4–6.)

1816. *Fusus longicauda* Bory, Enc. Meth., pl. 423, fig. 2.
1847. *Fusus longicauda* Reeve, Iconica, sp. 15.
1881. *Fusus longicauda* Tryon, Man. Conch., vol. III, pl. 38, f. 157.

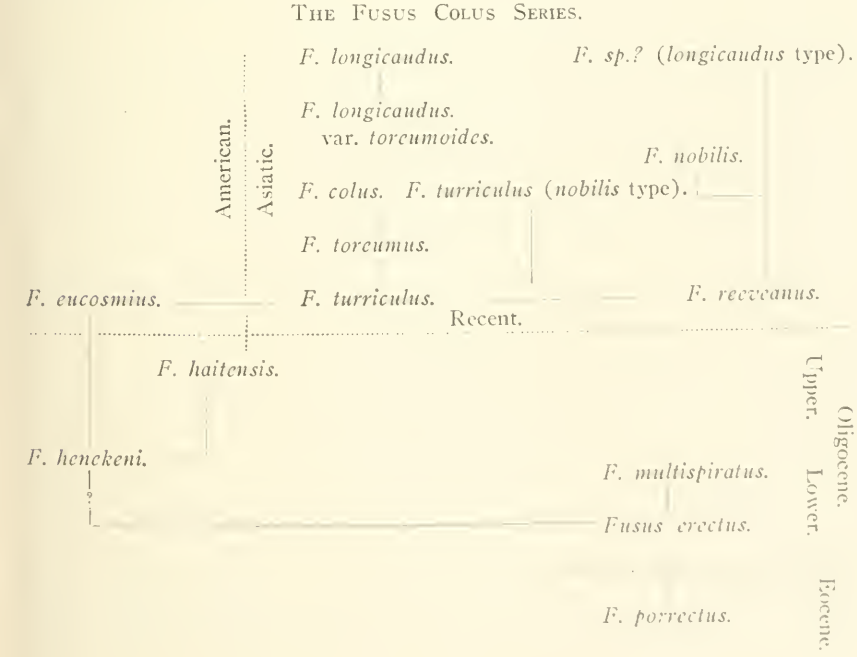
This species forms the terminal member of the series. The first nine or ten whorls of the conch are identical with *F. turriculus* in one specimen (M. C. Z. 906, Pl. II, fig. 6), while in others only seven or eight whorls are in the *turriculus* stage. On the succeeding whorls the striæ or spirals become more prominent, the ribs becoming fainter. This occurs generally first on the upper portion of the whorl, thus giving a shouldered expression to the shell. After that the ribs disappear entirely, and in the most typical specimen seen the last three whorls are ribless and marked only by spirals of two series. Intercalated spirals appear on the seventh or eighth whorl, but do not reach the strength of the primary ones. The central primary spiral

often becomes stronger than the others, thus producing a slight keel, and suggesting the *colus* stage.

The ribs are usually thicker and more closely crowded than on *F. turriculus* of the same size. They resemble more the ribs of the adult of that species. A greater crowding is the necessary result of the proportionally larger size of the ribs.

Two specimens from Ceylon (Phil. Acad.) are of a ruder type than the normal. The *turriculus* whorls recall those of *F. reeveanus* rather than those of *F. turriculus*. The ribs are broad, round and separated only by a depressed line. The sutures are not so deeply impressed as in *turriculus*, but partake of the character of *F. reeveanus*. A faint angulation appears in some of the neanic whorls, which in consequence take on a shouldered expression. This disappears in the last whorl, which is round and ribless with strong primary and slightly weaker secondary spirals.

It is possible that these specimens represent a *longicaudus* stage in development of a series beginning with *F. reeveanus*, and paralleling the series beginning with *F. turriculus*. If that is the case, these individuals will have to be made the types of a new species. Owing to the meager amount of available material, however, and because no authentic specimens of *F. reeveanus* have come under observation, no separation will be made at present.



Tryon (Man., v. III, p. 63) says of this species: "This is perhaps, a *F. colus* without carina or a *F. turricula* without ribs on the body-whorl." It is evident however that this is a distinct species occupying a definite place in the series.

Atavism occasionally occurs in this species, in the appearance of ribs of the *turriculus* type on the last whorl. There are seldom more than one or two of these.

Localities: Mauritius (M. C. Z. 906); Indian Ocean (B. S. 6080); Ceylon (Phil. Acad. Nat. Sci., n. sp.?).

The interrelations of the species of this series may be summed up as given in the preceding diagram.

3. FUSUS TUBERCULATUS AND ITS ALLIES.

FUSUS TUBERCULATUS Lamarck.

(Plate III, figs. 2, 3, 9.)

1822. *Fusus tuberculatus* LAMARCK, An. sans. Vert., 1st ed., t. VII, p. 123, no. 4.
1842. *Fusus tuberculatus* KIENER, Iconographie, p. 9, pl. VIII, fig. 1.
1843. *Fusus tuberculatus* LAMARCK, Desh. ed., t. IX, p. 444.
1847. *Fusus tuberculatus* REEVE, Iconica, sp. 38.

This species is closely related to *F. torcumus*, with which it appears to be genetically connected. The earliest conch stage of this species is the *turriculus* stage, essentially as in *F. torcumus*. This is succeeded by an angular stage, in which the characters are those of *F. torcumus*, the shell being much more slender than in the adult. The characteristic features of the species appear in the later neanic and ephebic stages.

The most characteristic feature of this species is the compressed character of the adult whorls, which gives the shell a broadly turreted appearance. The shoulder of the adult whorls is flat or even gently concave, devoid of ribs and margined by a strongly carinated keel. The beginning of the shouldered condition is variable; sometimes the early whorls take on an angular appearance, from the development of a strong central spiral; sometimes two strong spirals appear, causing bicarination.

In the adult whorls the nodules of the keel are generally compressed vertically, often assuming a spinose appearance. Sometimes, however, they assume a rounded form, resembling those characteristic of *F. undatus*.

In accelerated individuals the tubercles become confluent on the last whorl, producing a smooth keel. This is particularly well shown in a specimen from Indo-Pacific waters (Nat. Mus. 91740). This specimen is broadly turreted and shows a succession of round and ribbed, angular and ribbed, and angular and noduled whorls, each type grading into the other. In the last type the shoulder is very flat,

and it is continued for two and a half volutions. Then the tubercles disappear, and for something over half a volution only a keel occurs, with the shoulder somewhat rounded again. The rounding of the shoulder increases toward the aperture, at which the keel has practically disappeared (being indicated only by a strong spiral), and the outline of the lip has become a uniform curve. Similar features are shown by two specimens from Queensland (M. C. Z. 887). They are of the broadly turreted type which characterizes this species. The tubercles after continuing over two whorls become confluent into a carina. These cases show that the same succession of stages occurs in the series to which *F. tuberculatus* belongs as in that to which *F. torcumus* belongs. Both series undergo development in the same lines, producing parallel species, which are identical in characters which ought to be of specific value, but differ in characters of a higher taxonomic degree. In an extremely refined classification the series here designated would be considered as constituting distinct genera, the recurrence, in each series, of forms with the same specific characters being expected in conformity with the law of parallelism. The *colus* species, exemplified by the individuals above described, is not perhaps sufficiently established to become admitted to specific rank, according to the prevailing opinions as to what constitutes a species; nevertheless for convenience sake, in referring it to its proper place it will here be designated as *F. tuberculato-colus*.

In the Haines collection of the American Museum occurs a specimen even further advanced. In this the sharp nodes are entirely suppressed, there being but a moderate angulation over which the ribs continue to the ante-penultimate whorl. Altogether there must have been seven or eight round whorls, followed by two angular whorls, in which the ribs and nodes progressively disappear. The keeled character is continued for about a whorl—though faint and with faint nodulations— and is succeeded by nearly a whorl with round contour. The aperture is gerontic. This approaches very close to the *longicaudus* stage and might be called *F. tuberculato-longicaudus* for the sake of distinction. The form shows that it belongs to the present and not to the *colus* series.

The coloration of *F. tuberculatus* is a reddish-brown spotting between the tubercles. The shell is protected by a periostracum of a light brown color, furnished with papillæ at the points of intersection of the spirals and the lines of growth.

These shells are readily distinguished from the members of the *colus* series by the shorter and more broadly turreted spire, and by the shorter anterior canal.

Localities: Indian Ocean (M. C. Z. 30); Red Sea (M. C. Z. 885); Zanzibar (M. C. Z. 889); Mauritius (M. C. Z. 884); Queensland

(M. C. Z. 887, var.); Indo-Pacific (Nat. Mus. 91740, var.); no locality given (M. C. Z. 886, 888, 880).

FUSUS NODOSO-PLICATUS Dunker.

(Plate III, fig. 10.)

1867. *Fusus nodoso-plicatus* DUNKER, Nov. Conch. Moll. Mar., p. 99, pl. 33, figs. 3, 4.

1881. *Fusus tuberculatus* var. *nodoso-plicatus* TRYON, Man. Conch., vol. III, p. 54, pl. 34, fig. 110.

This species is of the general form of *F. tuberculatus,* but larger and more robust. The protoconch and early whorls of the conch are broken away in the only specimen seen. Between four and five of the remaining whorls are round, with round ribs and uniform spirals. Intercalated spirals appear in the second or third whorl. Two of the central spirals finally become strengthened, producing a double carination, a feature not uncommon in *F. tuberculatus.* An increased strengthening of the lower of these spirals produces the normal keel which becomes nodose where crossed by the ribs. These latter gradually disappear from the shoulder, which becomes flatter and flatter. Below the keel they remain in force somewhat longer, dying ..., however, downwards. The spirals are strong, and compound intercalation occurs while the shell is still young.

Some of the very robust individuals of *F. tuberculatus* resemble this species closely. This resemblance is even found in the coloration, which is similar in both species. The present species may be regarded as a vigorous descendant of *F. tuberculatus,* characterized by an accentuated development of the features of that species. Nevertheless it is more than a variety of *F. tuberculatus* as Tryon considers it.

Locality: Yenosima, Japan (M. C. Z. 894, Morse coll.).

FUSUS NODOSOPLICATUS var. LISCHKII var. nov.

(Plate III, fig. 5.)

1869. *Fusus nodosoplicatus* var. LISCHKE, Jap. Meer. Conch., pt. 1, p. 34, pt. 2, pl. 3, fig. 6.

This variety was first described by Lischke, who gives the following characteristics as distinguishing this form from the species. The characters of the young shell are identical with those of the typical form down to the sixth or seventh whorl. After this in the typical form the shoulders become flatter, and the ribs increase in thickness, forming tubercles on the shoulder angle. "In the variety, however, the ribs and tubercles scarcely increase in thickness in the seventh and eighth whorl, and after that begin to disappear. The two final volutions show only scattered indications of them, while the convexity of these whorls remains uniform, the last of these being well rounded."

"Occasionally the earlier volutions have the central spiral accentuated into a more or less strong keel. In the interspaces between the spirals occur from one to three transverse lines" (secondary spirals).

This variety, which occurs with the species, represents the accelerated type of this species. We note the same characters which we have seen in the *F. tuberculatus* and the *F. torcumus* series. The *colus* type occurs again in this species.

A small specimen of this variety from Japan (M. C. Z. 895, Pl. III, fig. 5) has the earliest whorls broken away. All the whorls are rounded, the earlier ones uniformly, the next ones with a bicarinate aspect, which merges into a unicarinate one, without, however, being strong enough to produce an angulation. Finally the carina becomes obsolete, the last whorl being uniformly rounded. Intercalated spirals appear in the third or fourth whorl. In the last whorl the ribs gradually become obsolete, the intercalated spirals at the same time becoming compound. The posterior canal is slightly developed and the lip is lyrate within. This shell represents a young individual, and its earlier whorls agree precisely with those of fig. 10 of the same plate.

This specimen may be said to represent the *longicaudus* stage of development in this series, bearing the same relation to *F. nodosoplicatus* that *F. longicaudus* bears to *F. torcumus*.

Localities: Japan Seas (Lischke); Yenosima, Japan (M. C. Z. 895, Morse coll.).

FUSUS PERPLEXUS A. Adams.

1864. *Fusus perplexus* Adams, Journ. Linn. Soc., Bd. 7, p. 107.
1868. *Fusus inconstans* Lischke, Jahrb. Mal. Gesell., I, p. 115.
1869. *Fusus inconstans* Lischke, Japan. Meer. Conch., pt. 1, p. 34, pt. II, Taf. III, figs. 1–6.
1831. Not *Fusus inconstans* Michelin, Mag. Conch., p. 33, pl. 33.
1879. *Fusus perplexus* E. A. Smith, Proc. Zool. Soc., p. 202.
1881. *Fusus perplexus* Tryon, Man., vol. 3, p. 54, pl. 33, figs. 102–107.

The Protoconch of this species has not been seen.

The conch begins with rounded whorls, crossed by rounded ribs and furnished with uniform but strong round or sharp spirals. The *tuberculatus* (or *torcumus*) stage is characteristically developed in the variety described by Lischke as *F. inconstans*, while the typical form of Adam's species shows the more advanced *colus* stage of this series.

Var. NAGASAKII var. nov.

(*Fusus inconstans* Lischke.)

The typical form figured by Lischke retains its angular whorls to the end. The ribs also continue to the last whorl where they become obsolete. Tubercles, however, continue to the end (Lischke, pl. II, figs. 1, 2). The keel of the type specimens is formed by the strengthening of three central spirals similar to that of *F. torcumus*. Accelerated

individuals of this variety have a portion of the last whorl without ribs or keel, being thus comparable to *F. colus*.

In typical specimens of this variety from Japan (Nat. Mus. 125894a, 123734a) the angularity of the whorls appears slowly, on the rounded regularly ribbed whorls of the early neanic stage. For about three whorls the angulation and ribs prevail together, after which, in the metephebic stage, the ribs disappear, while the keel still retains its strongly noduled character. Finally, in the parephebic stage, the nodules disappear, the keel remaining simple thereafter. This is the *colus* stage, and it is followed in one specimen by the early gerontic stage, in which the keel disappears too, leaving part of the last whorl uniformly convex (*longicaudus* stage). A specimen from Yokahama (Nat. Mus. 36554) nearly five inches in length, retains the nodulated keel to the end, though the ribs disappear in the last whorl. The shoulder of the adult portion of the shell is flat, and strongly delimited by the tuberculated keel. This is the most primitive (unaccelerated) individual of the species observed, and for the present series (that of *F. perplexus*) it represents what *F. tuberculatus* and *F. toreumus* represent for their respective series.

In the young of this and a number of other specimens a marked bicarinate aspect is imparted to the whorls by the strengthening of a spiral below the central one, which is itself strengthened. In one of these specimens this double carination is continued on later whorls after the appearance of the angulation. This feature appears to be true also of Lischke's typical specimens.

Connecting Lischke's with Adam's typical form are a number of intermediate forms, showing various degrees of acceleration. In some cases the angular ribbed whorls pass abruptly into angular whorls without ribs or nodes, a simple keel remaining. This passes into a keelless stage. In other specimens nodes or tubercles continue for a time, on the angular but ribless whorls, the whole merging gradually into a ribless, tubercleless and keelless round-whorled stage, where even the primary spiral is indistinguishable.

In all these specimens intercalated spirals appear early in the round-whorled stage.

The Typical Form.

(*Fusus inconstans*, var. LISCHKE.)

The essential characteristics of Adams' species are: " . . . anfractibus 7, convexis, longitudinaliter obsolete plicatis, transversim liratis, liris acutis aequalibus undulatis, lineis elevatis filiformibus alternantibus, liris transversis subnodulosis in medio anfractuum instructis." This is the variety which Lischke has named var. *minor* (I, pl. II, figs. 3–6). This "variety" falls again into several "subvarieties," which are comparable to the various species in the latter part of the *colus*

series. (The author uses the terms variety and subvariety here out of consideration for those who constantly declaim against the subdivision of species, on the ground that the subject is made too difficult for "beginners." The author, however, maintains that these "varieties" and "subvarieties" are entitled to specific rank, even though the intermediate forms are all present.)

The first distinct mutation is that corresponding to *F. longicaudus* var. *torcumoides* of the *colus* series. This, judging from the description, appears to be the mutation selected by Adams as the type of his species. It is the mutation illustrated by Lischke on plate II, fig. 3, of part I of his work on Japanische Meeres-conchilien. In this specimen the round whorls are succeeded by subangular ones, which in turn give way to nearly round whorls again. The ribs are absent on the last part of the last whorl. In a young specimen (M. C. Z. 920) the subdued angulation with its obsolescent nodules is continued to the eighth or ninth whorl, where it is succeeded by a smooth keel, which fades toward the aperture where the whorl is uniformly convex. This specimen is very like the young of *F. closter* (pl. III, fig. 1), differing from it chiefly in having its early whorls much less crowded than is characteristic of that species. The young of these two species are closely related.

Figures 4 and 5 of Lischke's plate II represent a variety in which the round-whorled, round-ribbed character continues to the end. This may possibly represent a form which has never passed beyond the primitive round-whorled *turriculus* stage, but it is more probable that it represents a highly accelerated individual in which the angular stage is entirely suppressed.

A specimen of this variety in the collection of the National Museum (40650) is more slender than the majority of these shells. The early whorls are well rounded, with round ribs, and strong sharp spirals, which continue to the end. Intercalated spirals appear in the fourth or fifth whorl, or even later (the apex of the shell being broken away), and they are first seen between the two central ones of the primary spirals. There is scarcely any angulation, a slight flattening of the shoulder, and accompanying obsolescence of the ribs being the only approach to it. The ribs occur at intervals, but they are very faint. A long slender anterior canal occurs.

This shell has a distinctly different aspect from the others of this series. In outline, character of spirals, apical angle and character of the anterior canal, it agrees closely with *F. nova-hollandiæ* from Australia, but the young is rounded, instead of bicarinate. The specimen is labeled from the Japan Sea.

Two specimens in the collection of the Museum of Comparative Zoölogy (920, 896) belong to this variety. In the first one the early

whorls are normal, and are succeeded by whorls in which the shoulder, though still convex, is but faintly marked by ribs, and is margined by a nodulated keel. In the last whorl the nodules disappear, and the center of the whorl is marked only by a smooth keel. Intercalated spirals appear early. The other specimen is also round-whorled throughout, but the shoulder is not differentiated. On the later whorls the ribs become obsolescent, after which the whorls are only marked by spirals. This specimen represents the *longicaudus* type of this series. This type is illustrated by Lischke in figure 5 of plate 3, Japanische Meeres-conchilien, pt. II.

In some cases (Phil. Acad. 62118) the early whorls of specimens referable to this species are more closely coiled than usual, when they bear a strong resemblance to those of *F. distans*. There certainly exists an intimate relation between these two species, they being undoubtedly genetically connected. Both run through the same series of variations, and the same types are distinguishable in each.

Localities: Japan, Nagami Bay (Nat. Mus. 125894, 123734); Yokohama (Nat. Mus. 32341, 36554, 98352, 91752) (Nat. Mus. 40650); Lagamo Bay (Phil. Acad. 62118); no loc. (M. C. Z. 896, 920); Tatyama (Adams); Jedo and Nagasaki, Japan (Lischke).

4. THE FUSUS DISTANS SERIES.

The members of this series are found to-day in both East and West Indian waters. They are characteristically robust shells, broadly turreted, and with strongly embracing whorls. They run through the same variations found in other series, and the types of structure so characteristically developed in the *F. colus* series are again found in this group.

FUSUS DISTANS Lamarck.

(Plate III, figs. 4, 6 and 7.)

1822. *Fusus distans* Lamarck, An. sans. vers., 1st ed., t. VII, p. 124.
1842. *Fusus distans* Kiener, Iconographie, p. 10, pl. 8, fig. 1.
1843. *Fusus distans* Lamarck, An. sans. vers. (Desh. ed.), t. IX, p. 445 (with bibliography).
1847. *Fusus distans* Reeve, Iconica, sp. 28.

The protoconch of this species is of the normal fusoid type. No perfect specimen has been seen, but one in which the last stages of the protoconch are shown occurs in the collection of the Philadelphia Academy of Sciences (loc. Philippines). In the last whorl of the protoconch of this specimen occur numerous smooth crowded vertical riblets, and it stops abruptly with a varix.

The conch begins abruptly with round whorls, which are furnished with round vertical ribs, closely crowded, with only a narrow depression between. The ribs are crossed by simple spirals, of which three

strong ones are visible at first, with a fourth one just below the upper suture. (The spirals do not begin as abruptly as in other species, for they are faintly shown on the last portion of the protoconch, where they are visible between the riblets, and even affect the last of the riblets themselves.) Intercalated spirals appear in the second whorl of the conch. The whorls are ventricose and at first very closely coiled, so that the suture in some specimens is scarcely impressed below the line of the whorls. In the fifth or sometimes the sixth whorl the shoulder becomes flattened, while frequently a strengthening of the central spirals still further accentuates the angularity. Sometimes from the strengthening of two spirals a bicarinate aspect is given to the shell, which later, from the subsidence of the lower one, gives way to a unicarination.

With the appearance of the angulation the ribs become fainter on the shoulder, and in the next whorl disappear altogether. The nodules, however, continue on the keel, becoming somewhat compressed vertically. In the final whorl, the vertically compressed tubercles are strong, and the shoulder is nearly flat. The primary spirals are strong, the secondary spirals are weaker, thus producing a distinct alternation. Sometimes compound intercalation occurs.

In one of the specimens from the Philippines (Acad. Sci.) the angulation never becomes as pronounced as in the normal shells. The shoulder remains convex, the tubercles disappear on the last portion of the final whorl, are replaced by a carina, and finally are only represented by a thickened spiral. This variety (the *colus* of the series), leads to *F. closter*. A similar individual, labeled *F. beckii* from Japan occurs in the Haines coll. Am. Mus. of Nat. Hist.*

Three specimens in the Jay collection of the American Museum (7975) almost completely represent *F. closter* of the West Indies, but they are labeled from the Red Sea. The last whorl is round, and the ribs on it are absent. The early whorls clearly show the *distans* features, but subdued. The later whorls become more rounded, and though a keel (or two) continues for some time, the round outline is more pronounced than any angularity.

This variety appears to be developed independent of the West Indian *F. closter,* which was developed from the West Indian representative of *F. distans.* The European *closter* type should have a distinct varietal name.

The American representatives of this species are generally slightly more accelerated than those from Indo-Pacific waters. They appear

*Citation of localities on labels of modern shells can seldom be trusted. Dealers and collectors will give as the locality the habitat of the species with which they identify their shell. Thus a wrong identification means generally a wrong locality. Examples of this may be found in all our large museum collections.

to assume the *F. closter* characters more readily, that species being the more characteristic representative of the series in American waters.

When the tubercles continue throughout in the West Indian species, the characters are generally those of the Philippine shells. The fine striæ occurring between the spirals of the Philippine shells also occur on those from the West Indies. The shoulder is often more sloping in the American shells, thus giving them a more slender and elongate appearance. A slight but broad concavity exists on the upper portion of the shoulder. There is some variation of the apical angle, which, however, often equals that of typical Philippine shells.

The tubercles generally become confluent into a well-marked keel, which is sometimes undulating, and sometimes smooth, and occupies from a fragment of a volution to two volutions or more. In almost all cases, the keel disappears towards the end, a uniformly rounded whorl, furnished only with spiral lines, alone remaining.

It will thus be seen, that whereas the *toreumus* type is the best represented type in Philippine waters, in American waters this is almost entirely replaced by the *colus* type. The *longicaudus* type, represented by *F. closter,* is most characteristic of the West Indies. It is therefore most probable that the American species were derived from the Philippine species, since the latter are the more primitive.

Localities: Philippine Islands (B. S. 260; M. C. Z. 892; Acad. Sci. Wilson coll.); Isle of Margarita W. I. (Phil. Acad. Sci. Swift coll.); Galapagos? (Acad. Sci.). This specimen was mounted with *F. dupetit-thouarsii,* with which it was wrongly identified. The locality given is typical for that species, but no *F. distans* has ever been reported from it, or from any portion of the west American coast.

FUSUS CLOSTER Philippi.

(Plate III, figs. 1 and 8.)

1850. *Fusus closter* PHILIPPI, Abbildungen, vol. 3, p. 115, pl. 42 (Fusus, pl. 5), fig. 1.
1881. *Fusus distans* var. *closter,* TRYON, Man., vol. 3, p. 58, pl. 36, fig. 132.

The protoconch of this species is of the normal type, the earlier portion smooth and erect, the last half volution with vertical ribs. These are narrow, faint at first, but sharper later on, and from two to tree times their width apart. There are seven or eight of these simple ribs, including the final varix, with which the protoconch ends. The riblets are very gently arched, with the convexity forward.

The conch begins abruptly, with a round-ribbed and spirally striate whorl. The ribs are generally strong, and closely crowded. In one specimen (M. C. Z. 919) a smooth space, somewhat wider than a rib, has been observed between the final varix of the protoconch and the first rib of the conch.

Three revolving spirals occur on the early conch, with an additional

one above, *i. e.,* below the upper suture, and another one below the main spirals, sometimes exposed, but generally covered by the edge of the succeeding whorl. The whorls follow each other in a close coil, which causes the sutures between them to be but slightly impressed, and gives to the spire a thick-set, less slender and graceful, and more embracing appearance.

By the end of the first volution of the conch the ribs have become less sharply defined, and the three main spirals have become stronger and sharper, with distinct and relative wide interspaces. Before the end of the second volution of the conch has been reached, the primary spirals have become very sharp on the ribs, and intercalated spirals appear between them. The spiral of the shoulder also becomes more distinct, while at the same time the shoulder takes on a more definite expression. The central one of the three primary spirals forms the shoulder angle. In a young specimen (pl. III, fig. 1) this angulation is continued till after the end of the seventh volution, after which, for the next half volution, the angulation becomes less pronounced and the ribs, which have been slowly becoming fainter, become obsolete. By the time that the ninth volution is reached, the outline of the whorl is practically a uniform curve, which is, however, slightly disturbed, by a subdued central carina or keel, formed by the strong primary spiral. There are, however, no nodes. The lip is strongly lyrate within, the liræ corresponding to the inter-spiral spaces. This variety is comparable to *F. longicaudus-torcumoides* of the *F. colus* series.

In an adult specimen (pl. III, fig. 8) the seventh and eighth volutions are less strongly angulated, the shoulder at the same time being more convex. The undulations of the subsiding ribs, are still faintly visible on some parts of the ninth volution, the shoulder having become so convex as to make a round whorl. Just below the suture, in the last three or four whorls, there is a narrow concavity, due to the formation on these whorls of a pronounced posterior canal.

The upper one of the three primary spirals is still strong on the ninth volution, thus diminishing the accentuated appearance still made by the central spiral. In the tenth volution the whorl is perfectly rounded, and after the manner of *F. dupetit-thouarsii* is strongly lined by the spirals. The ribs have completely disappeared, and the upper portion of the whorl has become slightly concave. Intercalation has become highly compound. The secondary spirals have nearly reached the strength of the primary ones, and are evenly spaced with them. Between these stronger spirals are five or more subequal fine revolving lines. Between these, on the final portion of the shell, are still finer ones, making in all from ten to fifteen fine revolving lines between each pair of coarser ones. These latter are themselves covered with from

two to five similar fine revolving lines. All these finer spirals show best on the periostracum, where they are accentuated by fine bristles, which arise at their junction with the growth lines.

The color of the shell is white, that of the periostracum a brownish olive when dry.

In a number of the West Indian specimens studied it was found that the keel and nodes are never developed, in the most accelerated individuals. The whorls remain round, with perhaps only a slight accentuation of the median primary spiral. The ribs continue sometimes into early maturity, but in all these accelerated individuals the last whorls are free from ribs, and without a keel. The whole tendency in the development of these shells is towards the dropping out of the inherited angular stage, and passing from a round-whorled and ribbed to a round-whorled and ribless stage. This accomplished, the *longicaudus* stage is reached.

F. closter was described from a specimen obtained from the Isle of Margarita. The illustration, however, which Philippi gives is not characteristic of the species as represented by large collections from that locality. The chief points of difference between this species and *F. distans* are given by Philippi in the following words: "Von F. distans Lamk. unterscheidet sich gegenwärtige Art durch den gänzlichen Mangel der Kante in der Mitte der Windungen und durch eine verhältnissmässig weit längere Spira" (vol. 3, p. 115). Among the specimens studied several were more slender than the Philippine species, but none as slender as the one figured by Philippi has been observed. If this unusually slender appearance is not due to a wrong perspective in Philippi's figure it is possible that his figure represents a specimen of *F. perplexus* substituted by mistake. His figure may very well stand for the accelerated variety of that species.

Locality: Isle of Margarita, West Indies (Acad. Sci., M. C. Z. 919?; 921? Nat. Mus. 54474).

The specimens of the *closter* type from the Red Sea in the coll. Am. Mus. Nat. Hist. are probably of independent origin.

5. THE FUSUS LONGISSIMUS SERIES.

FUSUS LONGISSIMUS (Gmelin) Lamk.

1780. *Fusus magnus,* etc., CHEMNITZ, Conch. Cat., T. 4, p. 177, pl. 144, fig. 1339.
1780. *Fusus longissimus,* etc., CHEMNITZ, do., p. 183, pl. 145, fig. 1344.
1788. *Murex canditus* GMELIN and *Murex longissimus* GMELIN, Linné, Syst. Nat., edit. 13, T. 1, pars VI, Vermes test., p. 3556.
1822. *Fusus longissimus* LAMARCK, An. sans. vers., t. VII, p. 122.
1842. *Fusus longissimus* KIENER, Iconographie, p. 3, pl. 2, fig. 1.
1847. *Fusus longissimus* REEVE, Iconica, sp. 4.

(If Gmelin is regarded as the authority for the species and not Chemnitz, who was not binominal, *canditus* should be the name of the species, as that precedes *longissimus*. Authors generally have followed Lamarck, however.)

This is one of the largest and most stately species of the genus. It appears to be a direct descendant of *F. nodosoplicatus*. The spire is elongate and slender, from the drawn-out manner of coiling. The first four or five whorls are round and furnished with round ribs, crossed by strong spirals. This stage agrees essentially with *F. turriculus,* and with the young of *F. torcumus, F. tuberculatus* and *F. nodosoplicatus*. It occurs as slender as the most slender of these, and its genetic relation to these species can not be questioned. The later of these *turriculus* whorls assume a subdued bicarinate aspect, similar to that found in *F. tuberculatus*. These whorls are soon succeeded by angular unicarinate whorls, on which a flat shoulder and a nodulated keel are developed. The ribs soon disappear, but the tubercles remain and increase in strength. They finally assume the character of rounded bosses which give a strong undulatory character to the keel.

Intercalated spirals appear very early, while the whorls are still round. In accelerated individuals the tubercles become obsolescent on the last whorl, and in some cases disappear almost entirely. The angulation also disappears in many cases, leaving a round ribless whorl. This is most frequently seen in old age individuals, where it is associated with other senile features, such as the separation of the inner lip from the columella, the increase in strength of the posterior canal, and others.

A unique specimen of this species is in the collection of the United States National Museum (cat. 73156). In this shell the *turriculus* stage continues to the tenth whorl. While the very youngest stages agree with *F. turriculus,* the succeeding differ to some extent. In addition to producing a more slender spire, they have broader, more elevated and rounded ribs. The interspaces are scarcely half as wide as the ribs, while in *F. turriculus* the ribs and interspaces are about equal. After the tenth whorl an angulation appears, and the ribs become obsolescent, but tubercles are retained to the end, and these alone mark the last three whorls. They are, however, not so prominent as are those of typical shells. The shoulder is very flat in the last two whorls, being even slightly concave towards the suture. The suture is always marked by a subsutural concavity, and a strong revolving subsutural band indicates a well-developed posterior canal. The final portion of the last whorl shows old age features, having lost the tubercles. Length of shell, 7¾ inches. It consists of about thirteen volutions.

A large specimen in the same collection (7377), which must have been almost eleven inches long, has the last six whorls angulated. After completing two of these volutions the ribs have disappeared, and then for nearly four volutions the flat shoulder, strongly noduled keel, subsutural band and relatively simple spirals characterize the shell. Old age characteristics are shown on the last portion of the last whorl.

Three spirals enter into the composition of the tubercles. The primary and secondary spirals have a uniform size in the adult portion of the shell.

An unlabeled specimen in the collection of the Museum of Comparative Zoölogy (cat. 891) represents a dwarfed form of this species. The spire is somewhat more slender and the knobs are somewhat smaller than in the normal form. Gerontic features, such as rounded whorl, crowded lines of growth, strong posterior canal and loose inner lip, appear fully a whorl earlier than in normal individuals. The spirals are like those of the normal form, being closely crowded and grooved, so as to appear compound.

The differences between this species and *F. nodosoplicatus* are given by Dunker as follows (p. 99):

"A Fuso (Murice) longissimo Gmel., haec nostra species statura multo minore, rostro breviore, costis spiralibus crassioribus minus acutis costisque tuberosis facile distinguenda est. Praeterea anfractus sutura multo profundiore disjunguntur."

Localities: East Indies (Nat. Mus. 73156, 7377); Indian Ocean (B. S. 226); Amboyna (B. S. 6079).

FUSUS UNDATUS (Gmelin).

1780. *Fusus longissimus glabratus angulosus* CHEMNITZ, Conch. Cab., vol. 4, p. 183, tab. 145, fig. 1343.
1788. *Murex undatus* GMELIN, Linn. Syst. Nat., ed. 13, tom. 1, pars VI, p. 3556.
1822. *Fusus incrassatus* LAMARCK, An. sans vert., T. VII, p. 124.
1842? *Fusus longissimus* var. *incrassatus* LAMARCK, KIENER, Iconographie, p. 4, pl. III, fig. 1.
1847. *Fusus undatus* REEVE, Iconica, sp. 12.

This species is the immediate successor of *F. longissimus*. The spire is long and slender as in the most elongate individuals of *F. tuberculatus*. The early whorls are of the *turriculus* type, round and furnished with round ribs. This is succeeded by a stage in which the young shell has all the characters of a *F. tuberculosus*. This is generally quite short, and is succeeded by a stage in which the characters of the immature shell are those of an adult *F. longissimus*. The ribs increase in prominence on the keel and finally become so strong as to affect shoulder and body alike, producing the strong undulations so characteristic of this species. In this last typical stage of the species the keel appears bulbous from the excessive development of the tubercles. Intercalated spirals appear in the sixth or seventh whorl, sometimes earlier.

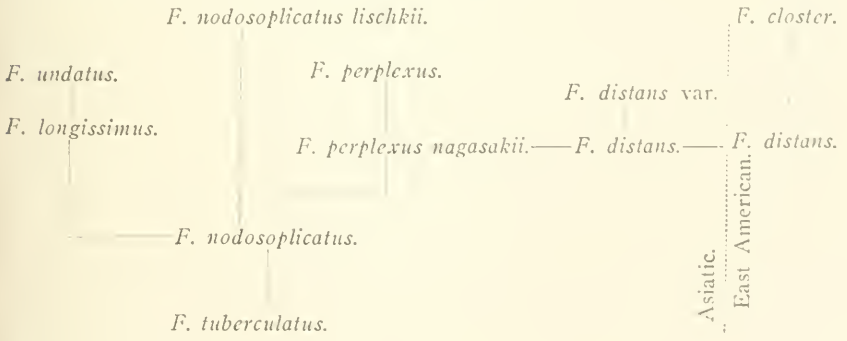
A specimen in the collection of the Boston Society of Natural History (cat. 223) represents a rather strongly modified variety of this species. The early whorls are round, furnished with round close-

set ribs and marked by both primary and secondary spirals. This stage rather more resembles the *F. reeveanus* type of whorl than that of *F. turriculus*. The angularity of the succeeding whorls is less accentuated in this variety, though the *longissimus* stage is well developed. After this stage the nodes become weaker, the ribs at the same time becoming obsolete. A flat or very gently convex shoulder remains, bordered by a keel free from tubercles.

This is probably an accelerated individual in which the *undatus* stage has been mostly replaced by a keel. On the other hand, it may be a case of premature senescence.

Localities: Pacific Islands (Nat. Mus. 36564, B. S. 220); Ceylon (M. C. Z. 882); East Indies (B. S. 223); Tahiti (Acad. Sci.).

The close relation between the preceding two species and *F. tuberculatus* is shown by the slender spire, which often recurs in the former species. The spire is that of *F. tuberculatus*, and it is particularly well reproduced in the Academy of Sciences' specimen of *F. undatus* Gmel. The relation is also shown in the *undatus* tubercles which sometimes appear on specimens of *F. tuberculatus* (see above). The spire of the specimens of the present series is not always nor perhaps even generally as slender as that of *F. tuberculatus*, and for that reason, as well as for the reason that *F. longissimus* is nearer in form and size to *F. nodosoplicatus*, it is best to regard the species of the present series as derived from *F. nodosoplicatus* rather than from *F. tuberculatus* direct. The relations may be expressed as follows:



6. THE FUSUS BECKII SERIES.

This series is to be traced directly to *F. tuberculatus*, the features of which are preserved in the early whorls of the species of this series.

FUSUS BECKII Reeve.

1847. *Fusus beckii* Reeve, Iconica, sp. 34, 34a (*F. ventricosus* Beck, Mss.).

The only specimen of this species which has come under my observation is in the collection of the Philadelphia Academy of Sciences.

This specimen corresponds so well with Reeve's figure 34b that it might almost be considered the figured specimen. The early whorls are round and rest upon each other, so as to produce a long and slender spire. The ribs are round and about their own distance apart. Intercalated spirals appear in the round whorls. The angulation of the *tuberculatus* stage appears early and quickly becomes prominent. The shoulder becomes strongly concave and reaches up onto the preceding whorl, thus producing a strong posterior canal. The principal spirals are reënforced by secondary ones, which appear on their sides. They become thicker and merge together, thus producing broad band-like spirals. The last whorl is ventricose and irregular, the nodes are still visible on the keel, and the lines of growth are irregular and strongly marked. The inner lip is separated from the columella and a strong posterior sinus is formed.

This shell has all the aspect of a *F. tuberculatus,* in which the spirals have become thickened. The canal has also become somewhat distorted.

Locality: Philippines (Acad. Sci., Dr. T. B. Wilson coll.).

FUSUS OBLITUS Reeve.

1842? *Fusus nicobaricus* KIENER (not LAMARCK), Iconographie, pl. VI, fig. 1.
1847. *Fusus oblitus* REEVE, Iconica, sp. 29.

No specimens of this species have been seen, but judging from the figures of Kiener and Reeve it appears to be a closely related species either to *F. tuberculatus* or to *F. beckii.* It lacks the final ventricose whorl of the last species, but has the same angle of spire. The strong coloration readily distinguishes this species from others of the series.

FUSUS NICOBARICUS Lamarck.

1788. *Murex Colus Nicobaricus variegatus* CHEMNITZ, Neues Conch. Cabinet, vol. 11, p. 241, tab. 160, fig. 1523.
1822. *Fusus nicobaricus* LAMARCK, Anim. sans Vert., t. VII, p. 123.
1847. *Fusus nicobaricus* REEVE, Iconica, sp. 37. Not *F. nicobaricus* KIENER, Iconographie, pl. VI, fig. 1.

This species is closely related to the two preceding, sharing with them the slender spire and other immature features. As many as six rounded *turriculus* whorls have been observed, on the later of which, however, the angulation is suggested by the occurrence of two rather strong spirals at the center of the whorl. The angular whorls are like those of *F. tuberculatus* (or *torcumus*) for a time, but with the suppression of the ribs the tubercles become stronger than those of *F. tuberculatus.* After this the characteristic broad spirals appear which link this shell with *F. beckii.* The nodes also become sharp and project from the keel. The shoulder becomes somewhat concave, and a pronounced posterior canal is developed toward the end. Sometimes

this is developed quite early, when its presence is indicated by a strong subsutural band.

The coloration of this shell consists chiefly in a "flaming" of a dark brown hue, and this and the strong spinose tubercles, together with the broad spirals, are the chief characteristics of the shell.

Localities: Loo Choo (Nat. Mus. 1056); East Indies (Nat. Mus. 7378b); Madras (B. S. 222, A. Binney).

FUSUS LATICOSTATUS Deshayes.

1831. *Fusus laticostatus* Deshayes, Magasin de Zoöl., p. 21, pl. 21 (1830).
1847. *Fusus laticostatus* Reeve, Iconica, pl. VIII, sp. 33a-b.

This species is generally of a ruder aspect than the preceding. The first five or six whorls are round, round-ribbed and ornamented with simple spirals which uniformly decrease in strength towards the sutures. Between some of the spirals secondary ones appear quite early. In many specimens the early whorls have a subdued bicarinate aspect from the increase in strength of the spiral below the central one. This finally subsides, and the whorls become unicarinate. At the same time intercalation becomes compound through the separation on each side of the main spirals of fine spiral lines, which later increase in strength. With this the ribs disappear but the tubercles remain. All the spirals become very broad, especially those on the shoulder and the principal body spirals. The secondary spirals also become broader than in any other species of the genus.

A number of specimens in the collection of the Philadelphia Academy of Sciences have the round-whorled stage represented by whorls which resemble those of *F. reeveanus* Phil. rather than *F. turriculus.* They are closely coiled, and the ribs are broad and separated by a mere depressed line. After six or seven of the round whorls the angulation appears and the ribs become obsolete except on the periphery, where they are continued in the tubercles. The spirals increase in thickness mainly through the combination of the secondary ones which arise on the sides of the primary ones.

These specimens may simply represent a variety developed under other than normal surroundings for the species, and are probably not directly related to *F. reeveanus.*

Localities: Indian Ocean (B. S. 263); Ceylon (M. C. Z. 879); Philippines (Acad. Sci.); no loc. (M. C. Z. 31, 881, B. S.; Acad. Sci.); Ceylon (Am. Mus. 8006; 8007).

The relations of the species of this series appear to be as follows:

F. nicobaricus. *F. laticostatus.*

F. beckii.

F. oblitus.

F. tuberculatus.

7. FUSUS DUPETIT-THOUARSII AND ITS ALLIES.

FUSUS DUPETIT-THOUARSII Kiener.

(Plate V, figs. 1–5.)

1842? *Fusus dupetit-thouarsii* KIENER, Iconographie, XIV, p. 5, pl. 11.
1847. *F. dupetit-thouarsii* REEVE, Iconica, sp. 9.

The protoconch of this species is of the normal fusoid type, consisting of about one and one-half volutions. The first whorl is smooth, obliquely erect and the apex partly covered by the succeeding whorl. The last portion of the protoconch is furnished with narrow smooth vertical ribs, more than their own width apart. On the last part of this ribbed portion of the protoconch two faint spirals appear in the center of the whorl. These spirals of the protoconch appear gradually, there being no line of demarkation between this part of the protoconch and that with simple riblets. No varix occurs at the end of the protoconch, but an abrupt change is noticeable. This is the most accelerated type of protoconch yet observed in *Fusus,* the appearance of the spirals placing it ahead of the other species of *Fusus,* except perhaps *F. distans,* in which very faint spirals appear between the last ribs of the protoconch.

The conch begins abruptly, with strong, wide and rounded ribs which are close together, the interspace being reduced to a mere depressed line. Several additional spirals appear, the two central ones, however, being strongest. As they increase in size, they soon give a bicarinate and subangular aspect to the whorl. This is the most characteristic feature of the young shell. Sometimes this bicarinate aspect of the whorls is marked from the beginning, at other times it does not become prominent until the third or fourth whorl. After the appearance of the bicarination the whorls become increasingly angular, the shoulder flatter and the ribs weaker. The bicarinate aspect continues through seven or eight whorls.

After this stage in the ontogeny is reached a divergence occurs which produces several varieties, which might well be considered distinct species.

Var. NODOSUS var. nov.

(Plate V, fig. 1.)

This is the most primitive variety of this species yet observed. It represents the *tuberculatus* (*torcumus*) stage of this series. The upper of the two central carina becomes stronger, and a more pronounced angulation appears. The ribs become obsolescent on the shoulder and on the body, remaining on the periphery only as nodules. These nodules continue to the end in the most typical individuals.

Intercalated spirals appear early, while the whorls are still bicarinate. In the later whorls, when the upper of the central spirals becomes the strongest, the spiral next above also increases in strength, so as to

correspond to the weaker of the two. Thus a symmetrical arrangement of spirals is produced, the central one being the strongest, while on either side occurs a weaker one. From this the spirals decrease in strength towards both sutures. Intercalation becomes compound and the interior of the labrum becomes strongly lyrate.

A number of specimens of this variety show a tendency towards obsolescence of the tubercles on the last part of the last whorl. These lead to the keeled variety.

In the collection of the Philadelphia Academy of Natural Sciences occurs a specimen which is unusually slender, but otherwise has all the characteristics of this variety. The early whorls agree precisely with those of typical individuals, but in the later whorls the shoulder is much more inclined. The ribs are obsolete on the last three whorls, which are characterized only by tubercles. This variety is to var. *nodosus* what *F. meyeri* is to the typical form of the species.

The Typical Variety.

(Plate V, figs. 2 and 3.)

This variety is the *colus* type of the series, the tubercles having disappeared, while the central carina continues strong. We have here an acceleration, the earlier stages being condensed. The angular noduled whorls (*torcumus* stage) pass gradually into the smoothly keeled whorls (*colus* stage), the occurrence of both stages on this shell constituting the *colus* type. The keel appears to be produced through a confluence of the nodes, which become elongate and flattened.

The spirals often become highly compound and the various lines being closely crowded, a broad aspect is given to the spirals.

This variety is connected by a *longicaudus-torcumoides* type with the *longicaudus* type (see Pl. V, where fig. 4 represents the former and fig. 5 the latter). In fig. 4 the angular whorls precede the round whorls, thus forming a connection between figs. 3 and 5.

Variety APLICATUS var. nov.

(Plate V, fig. 5.)

This variety represents the *longicaudus* type of this series. The carinated (*torcumus*) stage is wanting, this being a case of acceleration by elimination, as compared with the preceding variety which represented acceleration by condensation. In any normal series the latter always precedes the former. A slight flattening of the shoulder and the strong development of the two central spirals give the early whorls a subangular appearance, but the ribs continue uniformly across this angulation. The *torcumus* stage may then be considered dropped out in this variety, the *colus* stage succeeding the *turriculus*, and being succeeded by the *longicaudus* stage.

The stages of *Fusus dupetit-thouarsii* may be summed up as follow:

A. Protoconch.
   Smooth.
   Simple riblets.
   Riblets and two spirals.

B. Conch.
   1. Round whorled, round ribbed, non-carinate.
   2. Round whorled, round ribbed, bicarinate.
   3. Angular whorled, round ribbed, bicarinate.
   4. Angular whorled, ribless bicarinate-noduled.
   5. Angular whorled, ribless, unicarinate-noduled.
   6. Angular whorled, ribless, noduleless, unicarinately smooth-keeled.
   7. Round whorled, unicarinately smooth-keeled.
   8. Round whorled, keelless.

When stages 1 to 5 occur together, the *torcumus* type is produced (var. *nodosus*). When stages 1 to 6, or 1 to 7 occur together, the *colus* type is produced (typical var.). Omitting stages 3 to 6 inclusive gives us the *longicaudus* type (var. *aplicatus*), though this variety may also be produced by developing stage 6, and even stage 3. Thus these so-called varieties vary again in a perfectly regular and determinable manner.

In its general aspect this shell is readily distinguished from other species of the genus by its thick-set appearance, due to close coiling, and by its proportionally short, slightly sinuous anterior canal.

Localities: Pacific coast of America, Magdalina Bay (M. C. Z. 913); La Paz (M. C. Z. 912); Guaymas, West Coast Mexico (Nat. Mus. 23677, 56338, 32335); Galapagos Islands (Nat. Mus., 48419, dead shell); Puerto Libertad, Mexico (Nat. Mus. 152387); Carmen Island (Nat. Mus. 32334); Cape St. Lucas (Nat. Mus. 13932, 5394); Lower Cal. (Nat. Mus. 34512); no loc. (B. S. 221, M. Z. 911, 910, 909, Nat. Mus. 36565, 56334) (Phil. Acad. Sci.).

FUSUS DUPETIT-THOUARSII var. IRREGULARIS var. nov.

(Plate IV, figs. 5 and 6.)

The protoconch of this species is of the normal *Fusus* type, though appearing relatively larger. In all the specimens seen the apex was bitten by acid, and so the details of the structure of the protoconch could not be made out. Indications of the riblets have been observed, but whether the spirals were present on the last part of the protoconch could not be determined. It apparently ends in a varix.

The conch begins with ribs which are to all appearances bicarinate from the beginning. The whorls are otherwise round. The bicarination gradually gives way to a single carina, formed by the strength-

ening of the upper of the two spirals. This carination becomes very strong, producing a marked central keel. The ribs become gradually weaker and finally disappear, leaving the last two whorls ribless. The angulation of the whorls generally disappears toward the end. Some of the other spirals increase in strength, thus giving the shell a strong spirally striate appearance.

This species has the form of *F. colus* or *F. longicaudus* with the structure of *F. dupetit-thouarsii*. Its close genetic relation to the latter species can not be questioned, though the manner of coiling and the consequent form is very different. Just what relation this species has to *F. meyeri* Dunker is not clear, as no authentic specimens of the latter have been seen. Judging from the illustrations and descriptions, however, that species is quite distinct from the present one.

Three specimens of this species have been seen, and all are labeled as coming from the East Indies. They were all identified, however, with oriental species of *Fusus*, and the localities given can not be considered as quite trustworthy under the circumstances. Should the localities be correct, this species would constitute an important connecting link between the east- and west-Pacific Fusi.

It will readily be seen that the variations found in *F. dupetit-thouarsii* may again occur in this species. They have not been found, it is true, since the number of specimens examined is so very small, but it is easy to predict that in a large collection of specimens of this species all the normal varieties of the *colus* series will be paralleled.

Locality: (?) East Indies (M. C. Z. 940, B. S. 223). The locality is probably erroneous, the specimens having been labeled *F. longicauda*.

FUSUS MEYERI Dunker.

1869. *Fusus meyeri* DUNKER, Novitates, p. 127, tab. 43, figs. 1, 2.
1881. *Fusus meyeri* TRYON, Manual, p. 63, pl. 38, fig. 156.

The essential characteristics of this species are the following, according to Dunker. The slender shell consists of ten to twelve convex volutions which are uniformly white and separated by a deep suture. The upper whorls are strongly ribbed and noduled, but these ribs become weaker in the later whorls, and disappear wholly on the last one. Sharp raised spirals with finer ones between characterize the surface. Dunker states that this species comes nearest to *F. longicaudus*, referring undoubtedly to the form.

A specimen without locality (M. C. Z. 914) is referred to this species, though this reference may be questioned. It is a slender variety of *F. dupetit-thouarsii*, apparently standing between that species and the one described above as var. *irregularis*. The early whorls show the angular bicarinate stage merging later into an angular bicarinate ribless stage, which later is replaced by a unicarinate stage, in which the ribs

are represented chiefly by nodules. These disappear also, and a carinated stage remains. The carina slowly disappears, and the remaining whorls are round and marked only by strong spirals.

FUSUS AMBUSTUS Gould.

1853. *Fusus ambustus* Gould, Bost. Journ. Nat. Hist., vol. VI, p. 385, pl. 14, fig. 18.

The protoconch of this species is fusoid with narrow vertical ribs on the last portion. No distinction is shown in the specimens seen between the protoconch and the beginning of the conch, though in one specimen there appears to be an indication of a varix.

The conch appears to begin with three ribs which are slightly wider than those of the protoconch, but are not like those of normal young *Fusus*. It may be, however, that these ribs still belong to the protoconch, in which case the varix observed represents only a strengthened rib of the protoconch. Between the ribs last mentioned as perhaps belonging to the protoconch occur fine spirals, thus allying this species very closely to *F. dupetit-thouarsii*.

The whorls of the conch are at first round and the ribs uniform. Then the central spiral becomes strong and, soon after, the spiral next below becomes equally strong, thus producing a bicarination. The spiral below the center does not quite reach the strength of the central one, and the one above the center often becomes moderately strong, thus producing an obscure tricarination.

The largest specimen seen is nearly two inches long. The aperture and anterior canal combined equal in length that of the spire. The canal is slightly flexed.

There is a certain resemblance between the young of this species and that of *F. dupetit-thouarsii*. In the latter, however, the bicarinate aspect is more strongly marked, while in *F. ambustus* the bicarinate aspect is faint, owing to the strengthening of the spiral next above the center. Thus the angularity of the latter species is more normal, the central spiral being strong, while those on either side progressively decrease.

In one specimen where the inner lip is well developed, six faint columellar plications occur, which are disposed at a different angle from that of the spirals on the spindle, and not, therefore, produced by them. The influence of the spirals on the lip is seen, however, in the upper part of the aperture. In some of the other specimens faint indications of columellar plications occur, which are situated too far back to be due to the influence of the spirals. Similar faint plications occur on the young of *F. dupetit-thouarsii*.

Localities: West coast North America. Lower Cal., San Lucca cove (Nat. Mus. 32344); Topolobampo (Nat. Mus. 150864); Mazatlan (Gould).

FUSUS NOVÆ-HOLLANDIÆ Reeve.

1847. *Fusus novæ-hollandiæ* Reeve, Iconica, sp. 70.

The protoconch of this species is swollen and of the normal type throughout, with about two third volutions ribbed.

The conch begins with slightly angulated whorls which are furnished on the center with two strong spirals, thus giving the shell from the first a bicarinate aspect. The shoulder is furnished with two strong spirals, between which and the two central spirals are numerous fine intercalated spiral lines. The ribs in some specimens are at first weak, but subsequently become stronger, causing a subspinosity on the angle where they cross the spirals.

In a specimen from Port Jackson (Nat. Mus. 91743) intercalated spirals do not appear until the fifth whorl. In the sixth whorl a strong slightly convex shoulder occurs, which is ribbed and striate. The lower of the two central spirals is less prominent in this whorl than the upper, and the shell takes on a unicarinate appearance. This unicarination is visible in the two succeeding whorls, though it is less sharp. It also continues into the last whorl. The ribs finally disappear, and the last part of the last whorl is characterized by a slight angulation formed by a somewhat stronger central spiral.

The specimen here described agrees in all determinable characters with Reeve's figure of this species. It will be seen that there is a close similarity between this species and the young of *F. dupetit-thouarsii,* especially of the more slender varieties, in which the whorls are less embracing.

In the collection of the National Museum is a young shell which, with a number of specimens of *F. australis,* is labeled as coming from South Australia. The specimen is identical with the young of *F. dupetit-thouarsii* from the west coast of America, and it is possible that this specimen has been misplaced. If the locality is correct for this specimen, then it must be regarded as the young of *F. novæ-hollandiæ* (the only species with bicarinate young found in those waters). The canal of this specimen is strongly flexed, a character of *F. dupetit-thouarsii,* but probably not characteristic of *F. novæ-hollandiæ.*

Two specimens in the Haines collection of the American Museum appear to agree closely with Reeve's figures. The protonch is perfect and normal. Bicarination of the young shell is somewhat obscured by the strength of the spirals on the shoulder. Intercalation begins in the fifth or sixth whorl. An angulation appears toward the end of the volution where the shoulder becomes flat, and the ribs to some extent obsolete. In the nepionic and neanic stages the ribs are broad, and the interspaces mere depressions. In the final whorl the ribs become much swollen on the periphery.

F. spectrum may be a *colus* type of this series.

Another specimen labeled *F. longissimus* has carried the development a volution further (17364 Haines). The knobs become faint and the aperture is gerontic.

Localities: Port Jackson, Australia (Nat. Mus. 91743, 16625a?); Tasmania (Nat. Mus. 124169, 125169, 91744; M. C. Z. 901).

The relations of the species of this series may be expressed as follows:

F. dupetit-thouarsii irregularis. — *F. meyeri.* — *F. dupetit-thouarsii aplicatus.*
F. dupetit-thouarsii.
F. spectrum. *F. dupetit-thouarsii nodosus.* *F. ambustus.*
F. novæ-hollandiæ.

8. THE FUSUS LONGIROSTRIS SERIES.

The shells here classed together all belong to the Pliocene of Italy, where they are associated with the species of the *F. rostratus* series, with which they appear to be genetically related.

FUSUS LONGIROSTRIS (Brocchi).

(Plate VI, figs. 1–3.)

1814. *Murex longiroster* Brocchi, Conch. Foss. Subap., vol. 2, p. 418, tav. 8, fig. 7.
1856. *Fusus longirostris* Hörnes, Foss. Moll. Tert. Wien, p. 293, pl. 32, figs. 6–7 (with bibliography).

The protoconch of this species (pl. XVII, fig. 2 and 3) is unusually accelerated, consisting of at least two complete volutions, the second one with fine riblets throughout. In some specimens, however, the protoconch appears to be of the normal type. No indications of spirals on the protoconch have been noticed, but most of the specimens were so poorly preserved as to leave this point unsettled.

The conch begins with round whorls which are furnished with round ribs and with spirals. These rounded-whorls continue for two or three volutions, though in accelerated individuals like specimen, fig. 1, pl. VI, this stage is reduced to less than one volution, or may be dropped out altogether. Early during the round-whorled (*turriculus*) stage two spirals become strong on the center of the whorls, causing a bicarination. This is in all respects similar to the bicarinate stage of *F. dupetit-thouarsii.*

In the next succeeding stage the shoulder becomes flattened, while the spirals remain faint with the exception of one on the shoulder. The shoulder spiral nearest the peripheral carinæ becomes strengthened, so as to change the bicarinate into a tricarinate peripheral angulation.

The middle spiral (the upper of the two) finally becomes the strong central carina. The spirals on the body of the whorl are stronger than those on the shoulder.

The shoulder gradually becomes concave, and the ribs on it become gradually suppressed. They continue, however, on the shoulder angle, where they form strong but blunt and rounded nodules. Intercalated spirals appear on the shoulders in the third whorl.

A number of young shells in this stage have been found, but no adult shell of this series has been seen in which the development ceased at this point. If such were found, as may not be improbable, it would constitute the *toreumus* type of this series.

The next stage in the development of this species, is the *colus* stage, characterized by the loss of the ribs, as well as the nodules on the periphery. The shoulder, however, remains concave and no strong single spiral occurs, but rather several which produce a somewhat undefined angulation.

Figures 2 and 3 of plate VI represent this species in its typical form. In figure 2 the last whorl and a half are ribless, the shoulder is concave and the body of the whorls marked by strong spirals. This is slightly more accelerated than Brocchi's type, in which the ribs continue onto the last whorl. Figure 3 shows a specimen which is somewhat more accelerated than the preceding, and may be considered as representing the *toreumoides* type of this series. It has two ribless whorls, in the last of which the concavity of the shoulder is less marked. The *toreumus* stage is faint, though still visible.

Young specimens of this species which have been obtained from the Vienna Basin appear to be less accelerated than those from Italy. The round whorls continue longer and the ribbed and noduled whorls are more pronounced. It may be that the more primitive *toreumus* type occurs in the Vienna Basin. The specimens figured by Hörnes from that district (pl. 32, figs. 6, 7) are more primitive than the majority seen from the Italian localities. The ribs persist to the end and the shoulder is only faintly concave, there being only a moderate peripheral angulation.

The specimen illustrated in Hörnes' fig. 5, must be referred to *F. castelarquatensis,* though the early whorls show a faint peripheral angulation which is not found in the typical specimen.

A young specimen of this species from Bordighera, Italy (M. C. Z. 27797), shows a less degree of acceleration than is found in most individuals. The protoconch is slightly depressed, and consists of something over one and a half volutions. The last portion has smooth vertical riblets, rather far apart and without indications of spirals. The protoconch terminates in a varix.

The conch begins abruptly, with round strongly ribbed whorls, and strong spirals. Two of these are prominent from the beginning, but the shoulder can scarcely be called flattened. In the early whorls the ribs are strong and continuous from suture to suture, though most pronounced at the periphery. They are less than their width apart. The whorls continue rounded until after the fifth one, when the shoulder concavity becomes sufficiently pronounced to cause a peripheral angulation. The costæ also become faint and finally disappear on the shoulder, while numerous fine spirals make their appearance on this portion of the whorl.

A sectioned specimen in the collection of the Museum of Comparative Zoölogy has the characters of Brocchi's type of *longirostris, i. c.,* the ribs continue onto the last whorl of the adult shell, although the whorls are rounded. The section shows well a number of apical septa, a feature observed in almost every gastropod of this class which has been seen. In the present specimen, the last septum occupies the seventh (?) whorl, beginning three and one half volutions from the tip and extending backwards half a volution. The shell is thickened from within by the addition of layers which cover the liræ and other internal markings. The septa are formed by the separation of these layers from the shell and by a rapid constriction of these separated portions, thus forming a bag- or cornucopia-shaped end. This is generally rounded in the final portion, but sometimes it is angularly pointed. This end always rests on the bottom of the whorl. Six septa have been recognized, and there are probably two or three more which are obscured by the thickening of the shell or destroyed in the sectioning.

Localities: Bodighera, Italy (M. C. Z. 27797); Valleys about Luganiano, Castello Arquato, etc., Asti (M. C. Z. 1217, 27798?, 1223); Voslau Vienna Basin (B. S. 5138); numerous localities in Vienna Basin (Hörnes).

Horizon: Pliocene.

FUSUS CASTELARQUATENSIS sp. nov.

(Plate VI, fig. 4.)

Comp. Hörnes *Fusus longirostris,* Foss. Moll. Tert. Wien, pl. 32, fig. 5.

This species is to *F. longirostris* what *F. longicaudus* is to *F. colus.* It represents, therefore, the *longicaudus* type of this series. The earliest stages are those of *F. longirostris,* the whorls being round, bicarinate on the periphery, though not angular and noduled as in the young of the preceding species. The shoulder, however, becomes concave and the ribs begin to disappear toward the sutures. The last three whorls of this shell are ribless, round, except for a gentle concavity on the shoulder, and to all appearances quite smooth. There

are, however, strong spirals which are but little raised above the surface of the shell and which are subequally spaced. Between them are from five to three fine revolving lines. The whole surface ornamentation is subdued. A young specimen, locality unknown, occurs in the collection of the American Museum of Natural History. Hörnes' specimen from the Vienna basin (fig. 5) is much less accelerated than the type of the species here illustrated. It may, however, be referred to the same species.

Locality: Castelarquato, Italy (M. C. Z. 27795); Vienna Basin (Hörnes).

Horizon: Pliocene, Subapennine stage.

FUSUS INÆQUICOSTATUS Bellardi.

(Plate VI, figs. 5 to 7.)

1871. *Fusus inæquicostatus* BELLARDI, Moll. terr. Terz. Piedmont, p. 131, pl. 9, fig. 3.

This species comprises in itself a distinct series of shells which, though connected by intermediate forms, show nevertheless such marked stages that a number of distinct species could be made. The typical form of Bellardi comes nearest to fig. 6, pl. VI, while fig. 7 is further advanced, being a good gerontic representative of this series. Fig. 5 connects this series with *F. longirostris.*

Beginning with the typical form of *F. longirostris,* we derive this species by increasing the concavity of the shoulder, and the elevation of the shoulder-angle. A distinct revolving band is formed, bounded by the central and the upper primary spiral. This shoulder-angle or ridge becomes more and more elevated, and the shoulder becomes more depressed, so as to produce a flattening which finally culminates in a depressed canal. The shell also becomes compactly coiled and in consequence has a thickened irregular appearance which suggests *Cyrtulus serotinus,* or the general characters of the advanced species of *Clavilithes.*

This species in its extreme form represents the gerontic characteristics found in terminal members of most of the series of this class, and which consists of a loss of the graceful form from a loose wrapping round, as it were, of the later whorls about the earlier ones which still retain the normal form and features. These later whorls generally reach up on to the preceding ones, which they cover up in part or sometimes wholly.

Localities: Castelarquato and places about Asti, Northern Italy (M. C. Z. 27796, 1216).

Horizon: Pliocene, Subapennine stage.

Fusus longirostris and its allies have many characters in common with *F. dupetit-thouarsii* and its allies, especially in the accelerated

protoconch, the bicarination of the young, which is not characteristic of other species of *Fusus,* except the closely related *F. novæ-hollandiæ,* and the general form and character of the spindle. It is not improbable that *F. longirostris* is in the line of ancestry of *F. dupetit-thouarsii* and its allies. This suggests that the migration of the ancestors of the latter species occurred in Tertiary times, a supposition which needs for confirmation the finding of Tertiary species related to *F. dupetit-thouarsii* in American deposits. In this connection the following species is suggestive, but not conclusive.

FUSUS GABBI sp. nov.

1860. *Fusus henekeni* GABB, Journ. Acad. Nat. Sci. Phil., 2d ser., vol. 8, p. 350, pl. 45, fig. 31.

This species was originally described by W. M. Gabb, who referred it to *F. henekeni* Sowerby (see p. 19). It is, however, very distinct from that species, nor can its relation to *F. dupetit-thouarsii* be considered as proven. Gabb says it suggests "irresistibly" this species, but in this I differ from him most decidedly, though I admit that the general form and proportions are not unlike those of that species. The exact relation of *F. gabbi* to other species has not been determined, since the apex and early whorls of the only specimen known are in part broken away and in part badly worn. It may be a descendant of *F. longirostris* or it may be related to *F. henekeni,* but for neither of these suppositions is there any good evidence.

The youngest whorls observed are round, rather more embracing than *F. henekeni,* and have round and rather distant ribs. When still quite young the whorls become angulated at the periphery, this angulation being due to the strengthening of the central spiral. The shoulder becomes flattened and the ribs become obsolescent towards the sutures. Simultaneous with the angulation intercalated spirals make their appearance. On the final whorl, the ribs are reduced to mere undulations, the lip showing senile characteristics. These are accompanied by an irregular thickening of the lip and the formation of strong liræ within. Strong plications occur on the columella, but these appear to be due mainly to the influence of the columellar spirals, which are not obliterated by resorption or covered by a thick inner lip.

If this species could be shown to have ancestral relations to *F. dupetit-thouarsii* it would be of great interest, as showing the way by which the ancestors of that species reached the new world from their place of origin in the old. Such relationship is, however, not indicated, and we are at present left without any clue to the origin of *F. dupetit-thouarsii,* the most important American species of the genus.

Locality: Costa Rica (Phil. Acad. Sci. Gabb's type).

Horizon: Pliocene ? (Gabb).

FUSUS CLAVATUS (Brocchi).

(Plate VIII, fig. 15, see also fig. 13.)

1814. *Murex clavatus* Brocchi, Conchiologia fossile subapennina, T. 2, p. 418, tav. VIII, fig. 2.

This shell differs from *F. longirostris* chiefly in its rounded whorls which persist throughout. The whorls are round and furnished with simple rounded ribs, which in the young extend from suture to suture, but in the adult are only marked upon the periphery. The first three or four volutions have simple spirals, though a single intercalated spiral appears next to the suture in the third volution. The primary spirals are sharp and pronounced, the secondary ones very much smaller. In the last whorl very fine tertiary spirals appear.

Several varieties may be recognized. In Brocchi's type specimen the ribs appear to continue to the end of the final whorl, while the shoulder becomes slightly depressed. In a number of specimens from Asti and Castelarquato the whorls continue round, but the ribs disappear on the last volution, the spirals, however, remaining strong (fig. 15). In other specimens the shoulder becomes more depressed, the spirals stronger and the whole shell more robust (fig. 13). This leads to *F. etruscus*.

Localities: Asti (M. C. Z. 1213, 1215); Stazzano, Italy (M. C. Z. 1225); Castellarquato (M. C. Z. 1221).

Horizon: Pliocene (?), Subapennine stage.

The following variety was described (but not figured) by Basterot:

FUSUS CLAVATUS var. β Basterot.

1825. *Fusus clavatus* var. β Basterot, Mem. Soc. Hist. Nat. Paris, t. 2, p. 63.

"Testa transverse cingulata, striis filiformibus fere duabus interpositis; carina nulla; anfractibus rotundatis."

. . . "La var. β se trouve aux environs de Bordeaux."

This variety is the one figure on Plate VIII, fig. 15, while the variety figured in fig. 13 (var. γ) is accelerated. The type specimen represents an intermediate form.

FUSUS ETRUSCUS Pecchioli.

(Plate VIII, fig. 14.)

1862. *Fusus etruscus* Pecchioli, Di un nuovo fossile delle Argille Subapennine, Firence (with plate).

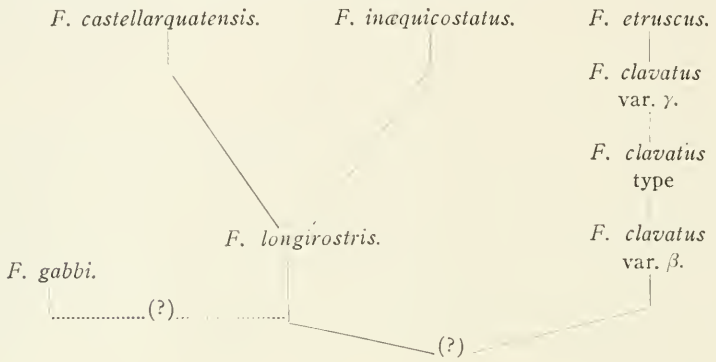
This large and robust species differs from *F. clavatus* in the angulation and nodulation of the whorls, and the very coarse spirals. The ribs persist through the last whorl, but are more of the character of undulations. Where crossed by the strong spirals they are coarsely nodulated. Lip strongly lirate.

This species bears the same relation to *F. clavatus* that *F. inæquicostatus* bears to *F. longirostris*. Both this species and *F. clavatus* may be regarded as members of a lateral branch from the radical of the *longirostris* stock.

Locality: Asti in Piemont (M. C. Z. 1214); Senese (Type in Regio Museo di Firenze).

Horizon: Subapennine stage (Etage 27), Pliocene.

The relations of these species may be expressed as follows:



THE FUSUS ROSTRATUS SERIES.

This series is represented in the Miocene and Pliocene of the Mediterranean region and by species living in the Mediterranean Sea to-day. The Tertiary representatives show a greater range of variation than do the recent ones, judging from a fairly extensive series of specimens seen and from published figures and descriptions. Several species may be distinguished both among the recent and the fossil forms, the gradation between them being, however, complete.

Pliocene Species.

FUSUS ROSTRATUS (Olivi).

(Plate VII, figs. 4–10.)

1792. *Murex rostratus* Olivi, Zoologia Adriatica, p. 153.

1856. *Fusus rostratus* Hoernes, Foss. Moll. Tert. Becken Wien, p. 290, taf. 32, fig. 2 (with synonymy).

1871. *Fusus rostratus* Bellardi, Moll. Terz. Piem., etc., pt. 1, p. 129, pl. 9, fig. 2.

The protoconch of this species is of the normal *Fusus* type, ending abruptly with a varix. The riblets on the last portion of the protoconch are narrow and rather far apart, leaving interspaces which are more than twice the width of the ribs.

The conch begins abruptly with round whorls furnished with strong round ribs which extend from suture to suture, and are crossed and

cancellated by strong spirals. In the succeeding whorls the ribs increase in strength, but continue to extend across the entire whorl. The central spiral increases slightly in strength, without producing an angulation. The shoulder also remains rounded. Intercalated spirals appear early, but do not reach the strength of the primary spirals. In some cases this intercalation becomes compound. Towards the end the ribs either grow stronger, leading to such forms as fig. 5, pl. VII, or else become obsolete, leading to such species as *F. semirugosus* Bell. et Mich. (Pl. VIII, fig. 9–12) and *F. cinctus* Bell. et Mich.

In general aspect, and particularly in the character of its ribs, this species is not unlike some varieties of *Clavilithes rugosus,* this Eocene species having attained the same degree of development which *F. rostratus* reaches in the Pliocene.

From the round-whorled variety, in which the strengthening of the central spiral alone marks the beginning of a peripheral angulation of the whorls, a branch leads to the strongly angulated forms which are typified by *F. bredæ* Mich. Even within the limits of the present species angular varieties may be recognized, in which the shoulder becomes somewhat flattened and the central spiral transformed into a keel (see pl. VII, fig. 4). Not infrequently the last whorl returns to the more primitive rounded condition with (usually) swollen ribs, which is probably a gerontic feature. Figure 5, pl. VII, illustrates a specimen in which this feature has been developed to an extreme degree. As far as the penultimate whorl, this specimen shows all the characters of an angular variety of *F. rostratus.* These features come to a sudden stop at a point which evidently marks an old break or injury to the shell. This resulted in the modification of the last whorl and ribs, which have passed into a condition in which they resemble the gerontic features of the last portion of a normal old age individual. The whorl itself is rounded and has strong rounded ribs which are more of the nature of regular folds than of ribs. These folds are separated by wide interspaces and extend from suture to suture. Towards the end they become strongly bulging, especially at the periphery of the whorl, where the last one of the ribs projects about a quarter of an inch. While at first these are true folds in the shell, affecting the interior as well as the exterior, they quickly become solid by the deposition of secondary calcareous material, so as to be no longer visible on the inside of the whorl. The spirals are strongest in the center of the whorl, where three of them are especially prominent. They decrease in prominence towards the sutures. Intercalation of spirals is compound.

This specimen shows that premature gerontism may be induced by injury, the resulting growth being similar in all respects to the normal gerontic growth in an old individual.

Figures 9 and 10 illustrate other forms in which the round swollen ribs are strongly developed. These approach closely to the variety *bononiensis* Foresti (Cat. Moll. Foss. Plioc. Bolognese, p. 32, tav. 1, fig. 10, 11), in which this feature is carried to excess.

Localities: Italy; Castellarquato, Luganiano, and Asti (M. C. Z. 1448, 1449, 1450, 1451); Orciano (M. C. Z. 27805–Pl. VII, fig. 5); Palermo (M. C. Z. 27807); Stazzano (M. C. Z. 1556); Sicily (Desh.); France; Touraine (Desh.); Vienna Basin (Hörnes).

Horizon: Miocene and Pliocene (?) Subapennine formation, Etage 27, north Italy.

FUSUS BREDÆ Michelotti.

(Plate VII, figs. 1–3, Plate XVII, fig. 4.)

1814. *Murex rostratus* Brocchi, Conchiologia Foss. Subapen., p. 416, tav. 8, fig. 1.
1847. *Pleurotoma bredæ* Michelotti, Foss. Mioc. Italie, p. 300, pl. 17, fig. 7. Not *Fusus bredæ,* ibid., p. 398, pl. X, fig. 8.
1856. Compare *F. rostratus* Hörnes, Foss. Moll. Tert. Beck. Wien, p. 291, p. 32, fig. 1, and *F. austriacus* Hoernes and Auinget, Gast. Oestreich Ungarn., p. 251, pl. 31, fig. 3. Not *F. bredæ* Hörnes, Foss. Moll. Tert. Beck. Wien, p. 284, pl. 31, fig. 1.
1872. *Fusus bredæ* Bellardi, Moll. Terr. Terz., pt. 1, p. 128, pl. IX, fig. 1, 1b.

This species represents an extreme specialization of a type descended from *F. rostratus.* The specialization lies chiefly in an accentuation of features, shown in progressive individuals of *F. rostratus,* but never very strongly developed. *F. bredæ* is a progressive type which has succeeded in carrying on the line of development begun by a certain section of *F. rostratus,* but generally abandoned when, with old age, the individual reverted to the more primitive and senescent condition of round whorls with swollen ribs. *F. bredæ* is an accelerated type when compared with *F. rostratus.* The features which in the latter species appeared only in the adult are in the former assumed and passed through quite early in life.

The protoconch is of the normal *Fusus* type, but somewhat depressed. It comprises one and a half volutions and ends with a strong varix. It is smooth except for the last portion of the last whorl, which is marked by narrow faint vertical riblets, which are rather widely separated (pl. XVII, fig. 4).

The first whorls of the conch are rounded and bear coarse rounded vertical ribs, separated by less than their width, and crossed by closely set rounded spirals. The two central spirals quickly become strengthened, thus giving the whole an angular character. Intercalation of spirals begins with the fourth volution of the conch.

The upper one of the two central spirals becomes stronger than the lower one, while at the same time the ribs of the shoulder diminish in strength, and the shoulder itself is flattened. The upper spiral in the adult stage becomes a spinous carina, the spines vertically flattened and

very strongly marked. In this stage the shoulder in the typical specimens is flattened and the spirals on it are numerous, fine and closely crowded.

Gerontism is marked in this species, as in the preceding, by a return of the whorl to the rounded, round-ribbed, primitive condition with the outer lip drawn into a strong rounded fold and the inner lip separated from the columella.

A very large shell apparently closely related to this species was figured by Hörnes (pl. 32, fig. 1) as a variety of *F. rostratus*. In this the asperations on the periphery are very strong, and the shoulder is moderately convex. There are about two and a half volutions more than in fig. 3, pl. VII, which resembles it. The specimen, with another, was found in the lower Tegel of Baden in the Vienna Basin, a formation considered of Miocene age. This species was afterwards separated by Hoernes and Auinger as *Fusus austriacus*.

Localities: Italy, Castelarquato; Asti in Piemonte (M. C. Z. 1452–1455, 27806); Baldissera, Grangia (Bellardi).

Horizon: Pliocene Subapennine formation, Etage 27. Also recorded from Miocene med. (Bellardi).

FUSUS SEMIRUGOSUS Bellardi and Michelotti.

(Plate VIII, figs. 9–12.)

1840. *Fusus semirugosus* Bellardi et Michelotti. Saggio Orittografico, p. 13, tav. 1, fig. 13.

1856. *Fusus semirugosus* Hörnes, Foss. Moll. Tert. Beck. Wien, p. 294, pl. 32, figs. 8–10 (with bibliography).

This is an advanced species of the *rostratus* stock, in which through loss of ribs in later whorls, a phylogerontic stage of development has been reached. It represents the terminal member of a lateral branch from *F. rostratus*.

The protoconch is fusoid, consisting of one and one half volutions ending in a prominent varix, and ornamented in the last half volution by fine closely set vertical riblets, which in some specimens are only seen with difficulty. The whorls of the conch are rounded with rounded vertical ribs, separated by concave interspaces of about equal width. The spirals, which appear suddenly after the end of the protoconch, are sharp, subequally distant and decrease gently in thickness towards the sutures. The interspaces are wider than the spirals. Intercalated spirals appear in the fourth volution of the conch. A slight angularity with a faint flattening of the shoulder appears in some of the later whorls, there being some variation in the age of the individual when these appear. A faint concavity occurs just below the suture, delimiting a subsutural band, which becomes quite prominent in the later whorls and indicates the presence of a posterior canal through-

out a greater part of the life of the individual. The ribs become obsolete on the fifth or sixth whorl of the conch, after which the whorls are only marked by faint spirals. On the ribless whorls the lines of growth are of about equal strength with the spirals, thus producing a cancellated appearance.

Localities: Sicily, Palermo (Coll. Wag. Free Inst. Sci. 4673); no loc. (M. C. Z. 1226); Torino (Bell. et Mich.); Voslau and Vienna Basin; rare (Hörnes); Lapugmy (Neugeboren).

Horizon: Lower Tegel, Miocene of Vienna Basin (Hörnes), Pliocene of Italy.

Hörnes figures a number of specimens from the Vienna basin under this name. In some of these the carina persists longer, thus recalling the figure of *F. cinctus* given by Bellardi and Michelotti.

FUSUS CINCTUS Bellardi and Michelotti.

1840. *Fusus cinctus* Bellardi and Michelotti, Saggio Orittografico, p. 12, tav. I, fig. 15.

This is apparently a closely related species which occupies an intermediate position between *F. rostratus* and *F. semirugosus*. It retains the carina or keel in all but the final whorl. The relation of these two species to *F. rostratus* was pointed out by the authors cited.

Locality: Asti.

Horizon: Pliocene.

Recent Species of the Fusus Rostratus Series.

FUSUS FRAGOSUS Reeve.

(Plate VII, figs. 12, 13.)

1848. *Fusus fragosus* Reeve, Iconica, pl. 19. fig. 71.
Compare *Fusus rostratus* Reeve, Iconica, pl. 14, fig. 55.
Compare *Fusus rostratus* Tryon, Man. Conch., vol. III, p. 61.

This is the most primitive existing member of this series. It is even more primitive than any of the species so far described from the Pliocene beds, though it is to be presumed that this species existed in Pliocene times.

The protoconch is less elevated than in the *colus* series, the whorls being somewhat compressed. The early portion is smooth, the later furnished with smooth vertical riblets. The total length of the protoconch is about one and one half volutions. The whorls of the conch are round in all stages, furnished with rounded ribs which in the earlier whorls are less than their width apart, but on the body whorl are separated by interspaces nearly twice as wide as the ribs. The spirals are strong and nearly uniform in the early whorls; the central one increases in strength in the later whorls, but never becomes strong enough to produce an angulation. Intercalated spirals appear in the fifth or later whorls of the conch.

Locality: Unknown (M. C. Z. 922).

Habitat: Mediterranean, 20 to 100 fathoms on corals and rocks.

In fig. 11 of plate VII a specimen from Palermo is shown which may be derived from this species, though from the imperfection of the young stages it is not possible to make a thoroughly satisfactory identification. In general, the immature whorls agree with those of *F. fragosus,* except that intercalated spirals occur only in the adult. The last whorl is without ribs except just behind the aperture where they may recur. The spirals are strong and subequal. The canal is rather short. If this variety really belongs to the present series it represents the *semirugosus* type among the existing members.

Locality: Palermo (M. C. Z. 926, 927).

Reeve's species 55 forms a connecting link between *F. fragosus* and *F. rostratus.*

FUSUS ROSTRATUS (Olivi).

(Plate VII, figs. 15 and 16.)

1792. *Murex rostratus* Olivi, Zoölogia Adriatica, p. 152 (Ginanni Adriatica, t. 2, tav. 7, fig. 56).

1883. *Fusus rostratus* Kobelt, Europäische Meeresconchilien, p. 52, pl. 9, figs. 6–10.

The original description is as follows:

"M. Stromdo di prima specie di colore biondetto formato ad angoli, e tutto recoperto di firmissimi cordoncini, che gli girano pel traverso.

"Abita diversi fondi, e predilige gli arenacei: Frequente.

"Si trova ancora lo *Strombo di seconda spezie rigato, e papigliato, di rostro curvo edi colore che inclina al carneo* dello stesso Gina Ginanna *tav. 7, fig. 57,* ed um'altra varieta piu ventricosa a coda *replicata,* e corta."

Olivi makes the type of this species the specimen figured by Ginanni in his Adriatica, t. 2, p. 8, tav. 7, fig. 56. I have not seen this publication, the date of which is 1774, but from the description cited it appears that the typical form is that with the carinated or angular whorl, as shown in figures 22 and 23 of plate VII. This is the common variety and may be regarded as typical.

Occasionally the central carina becomes strong, flat and projects beyond the others on the body whorl, being especially prominent where it crosses the round bulging ribs. The strengthening of the central spiral occurs at varying ages, sometimes in accelerated individuals appearing quite early. In such cases the body whorl often has an angular aspect, though the shoulder remains convex. (No recent species of this series with flat shoulder has been found among the collections examined, nor, so far as I can find, has any been described.)

In such accelerated individuals the intercalated spiral appears in the fourth or even the third whorl of the conch. In some specimens the intercalation becomes multiple on the body whorl, while the carination

becomes pronounced and vertically flattened as in the most advanced Pliocene species. The shoulder, however, never loses its convexity as it does in the fossil species, though it may become considerably depressed (fig. 21). Occasionally the ribs become obsolescent in the last portion of the body whorl. The more accelerated individuals approach *F. cælatus* Reeve (Iconica, pl. 8, figs. 35 *a–b*), which appears to be a variety of this series in which the spirals and ribs are both strongly developed, producing a striking appearance.

Locality: Mediterranean (M. C. Z. 923, 924, 925).

Habitat: 20 to 100 fathoms on corals and rocks (Tryon).

In the collection of the Academy of Natural Sciences in Philadelphia are a number of specimens labelled *Fusus rostratus* var. *carinata.* The specimens are from Greece and represent the most accelerated recent types of the series yet seen.

The protoconch is of the normal *Fusus* type with numerous crowded vertical riblets on the final portion and ending abruptly with a varix.

The conch begins with round whorls furnished with broad round ribs which are crossed by strong revolving lines of which five are usually visible above the suture, the fifth being often covered in part by the succeeding whorl. In the third volution, the central spiral develops into a prominent carina, the shoulder at the same time becoming flattened. The ribs also become more widely separated until they are about twice their width apart or more. They also become obsolete on the upper portion of the shoulder. Intercalation begins with the appearance of the angulation. The central carina attains almost the sharpness of that of the milder varieties of *F. bredæ* as shown in fig. 1 of pl. VII. The flattened shoulder and the prominent intercalations make the resemblance in some cases very marked.

It is a remarkable fact that the Pliocene varieties appear on the whole to be more accelerated than the recent ones. The flattening of the shoulder is rare in the recent varieties, nor have any specimens been seen in which the keel is as strong and sharp as that of *F. bredæ.* Furthermore, gerontic types like *F. semirugosus* are not as yet known in the recent fauna, though common in the Tertiary. If it is proved to be a fact that the Tertiary species are more specialized than the modern ones, for the determination of which large collections of recent and Tertiary specimens from all parts of the Mediterranean region are required, the explanation may be found in the independent development of the Tertiary series in a circumscribed provincial area. The highly specialized species are, so far as I am aware, recorded only from the Piedmont district, and the suggestion presents itself that the separation may have been due to the influence of the forming Apennine chain.

FUSUS CŒLATUS Reeve.

(Plate VII, fig. 17.)

1847. *Fusus cœlatus* Reeve, Iconica, pl. 8, sp. 35.

A specimen in the collection of the Philadelphia Academy of Sciences probably represents this species. The figured specimen from the collection of the Museum of Comparative Zoölogy also approaches this species.

The protoconch is fusoid, somewhat depressed and consists of only about one and a third volutions. The last third is furnished with riblets.

The conch has round whorls throughout, the ribs are rounded, at first less than their width apart, while on the body whorl they are nearly twice their own width apart. The sutures are deep and the anterior canal is slightly flexed. Intercalated spirals appear on the third whorl. The lines of growth form corrugations where they cross the spirals.

This species is probably to be regarded as a lateral branch from the *rostratus* stock.

The relations of these species may be expressed as follows:

F. cœlatus.	Var. *carinatus.*		
	F. rostratus.		
Recent.	*F. fragosus.*		
Tertiary.		*F. bredæ.*	*F. semirugosus.*
		F. rostratus.	*F. cinctus.*
		Fusus sp.?	

10. THE FUSUS AUSTRALIS SERIES.

This is a series of thick-set Fusi which appear to be genetically related to *F. distans* and *F. perplexus*. They are chiefly confined to the Indo-Pacific seas, but are represented on the American coast by *F. brasiliensis*.

FUSUS AUSTRALIS Quoy.

1832. *Fusus australis* Quoy, Voyage Astrolabe, zoöl., vol. 2, p. 495, t. 24, figs. 9–14.
1847. *Fusus cribrilratus* Reeve, Iconica, pl. 5, sp. 20.

The protoconch of this species has not been seen, but that of the closely related *F. brasiliensis* may be taken as typical of this species as well.

The conch begins with rounded whorls, the earliest of which have not been seen. The whorls are furnished with rounded ribs and the center is marked by two spirals which are more prominent than the others, because somewhat stronger, as well as somewhat farther apart.

A little later the upper of the two spirals becomes stronger, thus producing a unicarinate aspect. The ribs are at first strong and the spirals sharp and prominent, and between them, in the fifth or sixth volution, simple rounded secondary spirals appear by intercalation. The whorls gradually become bulging in the center and the ribs obsolete toward the sutures, but prominent in the middle. The simple intercalation continues for some time, after which from one to three additional ones appear on each side of the secondary spiral. The ribs generally become obsolete on the last whorl of the adult, and a not very prominent keel—the stronger central spiral—remains. In some cases the ribs are lost on the young specimen, showing individual acceleration.

In the younger specimens the spindle and anterior canal are proportionally longer than the spire, while in mature shells they are proportionally shorter. The striking feature of this shell is the vertically compressed character of the whorls which shortens and thickens it, giving it an appearance similar to that of *F. distans.*

In some adult specimens the prominence of the keel decreases, until the whorls appear round. In fact I am convinced that in a sufficiently large collection all the structural variations found in the *colus* series, will be represented. Parallelism appears to be the rule in the development of the species of *Fusus,* and it is to be seen in nearly every genetic series within the genus. The shells of the present species are covered with an olive brown periostracum.

A specimen in the Philadelphia Academy of Science collection has the characters and outline of this species with a bicarinate young, but it has its spirals noduled in a striking manner, which is wholly unlike that of normal specimens of the species.

The radula of this species is much like that of *F. inconstance* Lischke, the central teeth being slightly different.

Localities: South Australia (M. C. Z. ——, Nat. Mus. 91749, 16635) ; Indo-Pacific (M. C. Z. 34, Acad. Sci.).

FUSUS BRASILIENSIS sp. nov.

(Plate IV, figs. 1 to 4.) (Type fig. 2.)

The protoconch of this species is somewhat less oblique than the normal, appearing slightly more depressed from above. It consists of one and one half volutions, the last portion of which are furnished with vertical riblets, which toward the end become strong. The whole aspect of the protoconch recalls that of the Italian Tertiary Fusi.

The conch begins with rounded whorls, which at first are less bulging in the middle than those of the preceding species. The shell thus appears more cylindrical in the young. There are two strong central spirals visible, giving the appearance of bicarination. There are really three of these strong peripheral spirals, the lower one, how-

ever, being covered up by the next succeeding whorl. Above these central spirals on the shoulder are three other spirals, the third of which is next to the upper margin of the whorl. The ribs are faint, being more of the nature of undulations, broadly rounded and with narrow concave interspaces. On the latter part of the third volution an additional (fourth) spiral appears between the upper marginal one and the one just below it. A little later intercalated spirals appear between the three central primary spirals.

With continued flattening of the shoulder the upper of the two exposed central spirals becomes stronger, and projects above and beyond the others as a strong keel. By intercalation and separation of secondary from primary spirals, the appearance of highly compound intercalation is produced. The lines of growth are strongly marked, producing a vertical striation, which serrates the spirals. The ribs fade away toward the sutures, being strongest and sharpest on the angle. In some of the less accelerated specimens the whorls remain round longer, the angularity scarcely becoming pronounced until the ephebic stage is reached.

Accelerated individuals show a loss of angulation and tubercles in the last whorl. One specimen (M. C. Z. 947a, Pl. IV, fig. 4) has been seen, in which the ribs are absent from the last two whorls, and the angulation absent from the last whorl. This represents an advanced *colus* type of this series (*i. e.*, the *colus* variety of this species). It almost approaches the *longicaudus* type, which would be reached as soon as the angular ribbed whorls are suppressed or replaced by rounded ribbed whorls. In this, as in all the other series, whether they be considered series of species (as would be most proper) or series of varieties, or even subvarieties, the same order of variation prevails and the same types of mutations (or more correctly the same types of species) are reproduced.

The color of the American specimens of this species is white, with orange tipping on the tubercles. The coloration extends in a weak stream downward and upward from the tubercle, but soon dies out.

A variety from off Cape Frio (M. C. Z. 961) shows a development comparable to *F. longissimus*. It represents the opposite extreme from that shown in the *longicaudus* variety of this series (M. C. Z. 947a), and represents a progressive rather than a retrogressive type. It agrees with the normal form in the protoconch and early whorls, but the shoulder becomes more concave, and the tubercles become vertically flattened and strong. The spirals become faint to obsolete on the shoulder. This variety has quite a distinct aspect, but it is clearly a modification of the normal type.

In some of the specimens of this series the ribs become bulging on

the last whorls, and the spirals become sharp. This variety seems to form a connecting link between this species and *F. marmoratus.*

Localities: Brazil (M. C. Z. 945 type; 945a, 947, 948, Thayer and Hassler expeditions); Florida? (M. C. Z. 946 Wurdemann shells); off Cape Frio, Brazil (M. C. Z. 961, dredged in 35 fathoms, Hassler Ex.); no loc. (M. C. Z. 949, 950, 950a); Suez? (B. S. 2506, Chickering coll.).

FUSUS MARMORATUS Philippi.

1847. *Fusus marmoratus* PHILIPPI, Abbildungen, Bd. 2, p. 120, pl. 24, fig. 7.
1847. *Fusus marmoratus* REEVE, Iconica, pl. 1, fig. 1, 1*b*.

The protoconch of this species has not been seen, but it is probably of the nature of that of *F. brasiliensis.*

The conch begins with round whorls which are separated by moderately deep sutures. They are shorter than wide. The ribs are round, close set and reach from suture to suture. The interspaces are concave and narrower than the ribs. In the next stage an angulation appears, and with it intercalated spirals. The primary spirals are narrow, sharp and distinctly subspinose on the ribs. With the appearance of the angulation the ribs become obsolete below the angle as well as gradually above it. Sometimes, however, they persist to near the end.

In a specimen from the Gulf of Suez (M. C. Z. 942) the ribs are strongly developed on the penultimate whorl, but become obsolete on the body and shoulder of the last whorl. They remain strong, however, on the periphery, where they include from one to three spirals, which are thicker and stronger than the others, and which produce the noded projections on the keel. The coloration is mainly on the ribs.

This specimen represents the *toreumus* type of this species (series) never passing beyond the primitive angular stage. It is the most primitive variety of the species.

In another specimen (M. C. Z. 943) the peripheral angulation is formed by two strong spirals, of which the upper one is the stronger. The anterior canal of this specimen is rather shorter than that of most specimens.

In the Red Sea occurs a variety (described below) which shows some marked differences. It has been identified with *F. multicarinatus* Lam. as figured by Kiener, but with this identification I can not agree. It may be wise to separate this as a distinct species from *F. marmoratus,* although it is difficult to state just wherein lies the difference. The variation is not one due to acceleration in the development of a distinct series, but is rather a variation in those characters which will produce a new genetic series. In a refined classification the variation is to be considered as generic rather than specific. Nevertheless, although this

shell marks the beginning of a new series, the variation has not as yet become pronounced enough to enable one to state its characteristics precisely.

FUSUS MARMORATUS var. *β*.

This variety differes from the preceding in being more angulated in the young, when the whorls are rather strongly bicarinate. The shoulder is flat, though strong spirals detract somewhat from the flat apearance. Intercalated spirals appear on the fourth or fifth whorl, and later become compound. In the adult whorls the ribs generally become obsolete, first fading toward the sutures and later wholly disappearing except on the keel, where they produce the nodules. The spirals are sharp and somewhat serrated by the lines of growth.

There is considerable variation due to the earlier or later suppression of the ribs. Sometimes the angulation of the early whorls is less strongly marked, and then the specimen resembles the typical *F. marmoratus*. In some specimens the ribs disappear before the adult stage is reached, and in the majority of specimens seen the last portion of the last whorl is keelless as well.

From the material so far seen two types of variation may be distinguished. The *torcumus* type retains the ribs towards the end, where they are represented by the nodules on the keel, while the *colus* type has the last whorls ribless and without tubercles on the keel. If the present variety is considered as a species, the several mutations, which mark distinct stages of development, must be considered as distinct varieties. In this, as in all the previous cases, acceleration is responsible for the production of these mutations, and it will thus be seen that, although the actual difference between this shell and the normal *F. marmoratus* is not so very great, being perhaps mainly what may be called a provincial mutation (*i. e.*, a variety developed in a separate province, cut off from the mother form), it has nevertheless begun to develop an independent series.

Judging from Kiener's figure the type of *F. multicarinatus* has a longer canal, and has only simple spirals. It is also less spinose in appearance than this variety, and the coloring is more uniform.

A rather striking specimen of this species is in the collection of the Boston Society of Natural History (228). The early whorls are round and the ribs rather narrower than in the preceding specimens. Angulation and intercalated spirals appear in the fourth whorl. The ribs are rather widely separated for this species. The shell is somewhat corroded, and does not show sharp surface characters nor coloration. Just below the suture on the shoulder the whorl is marked by a depressed band, which in the last whorl becomes a slightly depressed canal or canaliculated interspiral space, containing two secondary spirals. In the last part of the last whorl the ribs are in the form of vertical

wrinkles, which are aciculate where crossed by the spirals. The intercalated spirals become compound in the adult.

This specimen represents a gerontic individual of this species, containing an additional whorl above what is usually found in the species.

In the typical *F. marmoratus* the old age characteristics consist in a loss of the angulation, a wrinkling of the shell, a loosening of the inner lip and the consequent formation of a pseudo-umbilicus.

Fusus australis and *F. marmoratus* are closely related, but I do not agree with Tryon who unites them. The specimens from the Red Sea partake of the character of both, while the Brazilian species is closely related to that from the Red Sea.

The young of *F. marmoratus* are on the whole more rounded, and perhaps more bulging at the center, with a slightly deeper impressed suture and less flattening of the shoulder. The coloration of *F. australis* is more uniform, and not so marked as that of *F. marmoratus*. The canal is also generally longer in *F. australis*.

Localities: Australia (M. C. Z. 897); Gulf of Suez (M. C. Z. 942); no loc. (M. C. Z. 943); Red Sea (M. C. Z. 898). Var., Red Sea (M. C. Z. 899?, 944); East Indies (B. S. 228).

In the Haines collection of the American Museum of Natural History are a number of specimens which appear to belong to this variety. They are labelled as coming from Australia.

The protoconch is of the normal form, obliquely elevated, with fine riblets on the last two-third volution, and ending in a varix. The whorls of the conch succeeding are round, with regular rounded ribs. Of these there are four or five in the best specimens seen, or fewer in others. They are bicarinate at the periphery, two spirals being stronger. This bicarination persists in some specimens, while in others from the strengthening of one of the spirals a simple angulation is produced. The ribs become obsolete in the last whorl, but the spines are prominent on the angle. Intercalation has become highly compound in the last whorl, and the lines of growth are also prominent.

The spirals of the body whorl along the line of the suture of the succeeding whorl become strong so as to produce a second angulation, which, though not very prominent, is nevertheless a recognizable feature of these specimens. An accentuation of this feature, together with an accentuation of the spines and a corresponding backward pushing of all stages (acceleration), produces *F. poligonoides*.

FUSUS MACULIFERUS Tapparone Canefri.

1830. *Fusus colus* Deshayes, Encyclop. Meth., pl. 424, fig. 4.
1875. *Fusus maculiferus* Tapparone Canefri, Muricidi del. Mar. Rosso, p. 626.

This specific name was proposed by Tapparone Canefri for the variety of *F. tuberculatus* figured in the Encyclopedie Methodique, as

F. colus. It has a second angularity at the base of the body whorl. This species connects *F. tuberculatus* with the Red Sea variety of *F. marmoratus,* and with *F. polygonoides.*

A number of specimens in the Haynes collection of the American Museum of Natural History (7999) labeled as coming from the Philippines, appear to belong to this species. They show the same angularity at the base of the body whorl, though all the other characters are those of *F. tuberculatus.* This, therefore, may be considered the radicle of the present series.

Locality: Red Sea (Tapperone Canefri); Philippines (Am. Mus. 7999).

FUSUS POLYGONOIDES Lamarck.

1822. *Fusus polygonoides* LAMARCK, An. sans vert., T. VII, p. 129, sp. 22.
1847. *Fusus polygonoides* REEVE, Iconica, sp. 36.

Only a few specimens of this species have been seen, none of them showing the protoconch. Some doubt may be entertained as to the exact generic relations of this species, yet in the absence of definite evidence we will range it with the preceding species of *Fusus.* It appears to be an excentric type of the genus, most nearly related to the angular varieties of *F. marmoratus.* Both varieties, the long and the short, are represented in the specimens seen, corresponding to the figures given by Reeve.

The early whorls are round, thick and close together. The ribs are round, and about their own width apart. There are six primary spirals visible. In the sixth or seventh whorl angulation appears, the central spiral becoming prominent and the ribs fade towards both sutures. On the last whorl the ribs have practically disappeared from the shoulder, but on the angle they form strong, sharp and prominent conical tubercles. A second row of tubercles occurs on the body of the whorl, formed by the fourth spiral below the shoulder angle. In all but the body whorl this second row of tubercles is covered by the next succeeding whorl. Intercalation is of the very mild kind, occuring only on the last whorl and not even there between all the spirals. In the shorter variety intercalation is more pronounced and occurs somewhat earlier. The shoulder of this variety is less sloping than that of the longer type.

In the collection of the Philadelphia Academy of Sciences are a number of specimens which appear to be bleached varieties of this species, with the shoulder gently convex and the second row of tubercles rather subdued. The label accompanying this lot reads as follows: "Between Cairo and Suez, far from the sea are immense banks of these shells, from which it is inferred that the Red Sea formerly extended there" (E. R. Beadle).

In character these are intermediate between *F. marmoratus* var.

β and the present species. Another specimen, probably of this species, is from the Arabian coast.

Localities: East Indies, Red Sea (Phil. Acad. Sci.).

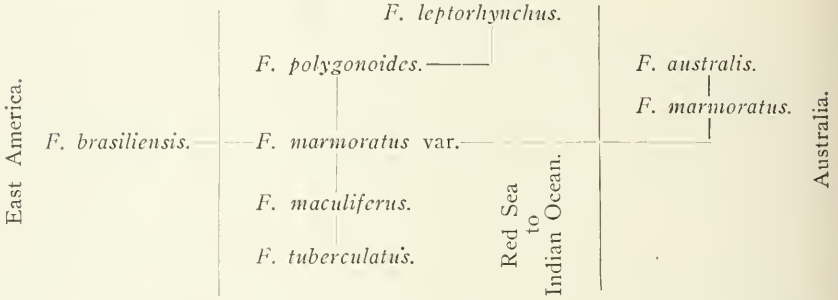
FUSUS LEPTORHYNCHUS Tapparone Canefri.

1875. *Fusus leptorhynchus* Tapparone Canefri, Muricidi del. Mar. Rosso, p. 627, pl. 19, figs. 5, 5*a*.

This species has the characters of an elongated *colus*-like *F. polygonoides,* with which Tapparone Canefri compares it.

Locality: Red Sea (Tapparone Canefri).

The relations of these species of this series may be expressed as follows:



11. SPECIES OF FUSUS WHOSE PRECISE RELATIONS ARE UNDETERMINED.

FUSUS SCHRAMMI Crosse.

1865. *Fusus schrammi* Crosse, Journ. Conch., T. 13, p. 31, t. 1, fig. 9.
1881. *Fusus schrammi* Kobelt, Monograph Fusus, p. 172, taf. 53, fig. 4.

A good description of this species was given by Crosse, and to this only a few words need be added in this connection.

The shoulder is gently concave, the shoulder angle sharp and furnished with spines. The ribs are marked on the earlier whorls. The peripheral keel is made of two close-set spirals. The lines of growth pass forward near the suture.

A worn specimen bears a striking resemblance to the Miocene *F. spinifer* Bellardi of the Italian Tertiary. The large number of spirals on our species easily distinguish it even when worn.

A single specimen of this species occurs in the collection of the Philadelphia Academy of Sciences.

The protoconch appears to be of the normal *Fusus* type, but there is a suspicion of an indication that the riblets which appear on the last part of the whorl extend farther up on the protoconch than is normal. This suggests relation to *F.* (*Heilprinia*) *caloosaensis.* The form of the shell indicates, however, a normal *Fusus.* All the whorls are round. The ribs are rounded and more than their width apart. Inter-

calated spirals appear early, possibly in the second whorl. The lines of growth produce strong cancellations. On the last whorls the ribs have disappeared, and the spirals have become compound from repeated intercalation. The lines of growth crossing these produce a lattice type of cancellation.

Locality: U. S. Fish Com. Sta. 2676, 407 fathoms on fine sand off Cape Fear N. C. 45.8° F. temperature. 2 spec. (Nat. Mus. 87487).

Habitat: Guadaloupe, W. I. (Crosse).

FUSUS HALISTREPTUS Dall.

1889. *Fusus halistreptus* DALL, Blake Moll., vol. 2, p. 168, pl. 35, fig. 7.

This species was well described by Dall. The early whorls have a distinct bicarinate aspect from the strengthening of the spiral below the central one. Intercalation begins in the earliest whorls preserved in the specimen. In the later whorls the shoulder becomes flattened and the ribs become subdued, being far apart and narrow. In the early ephebic whorls the flattening of the shoulder is arrested, but the central spiral continues as a keel which is sharply noduled by the faint ribs which persist throughout. The primary spiral next below the central one repeats the characters of the latter in a milder manner. In the final whorls the shoulder becomes relatively more convex, and the intercalations triplicate.

Locality and Habitat: U. S. Fish Com. Sta. 2655, living in 338 fathoms, Little Bahama Bank, bottom sandy. Temp. 47.5° F. (Dall) (Nat. Mus. 93333).

FUSUS COUEI Petit.

1853. *Fusus couei* PETIT, Journ. de Conch., T. 4, p. 249, pl. 8, fig. 1.
1889. *Fusus couei* DALL, Blake Moll., vol. 2, p. 167.

The specimens seen of this shell are smaller than Petit's specimen. The shoulder slopes more upward, the suture is less impressed and the spirals are less strong.

The protoconch is somewhat depressed and not so typically Fusoid as in the species of *Fusus* generally. There are two whorls, the second with fine narrow riblets which pass downward about a third the width of the whorl, then forward, forming at first a concavity and then becoming gently convex, thus describing an outline like a reversed letter S. The riblets become more closely crowded and broader toward the end of the protoconch and no strong varix appears. The protoconch thus appears to merge into the conch. The ribs of the early conch are broad, low and rounded, with a mere linear depression between them. They extend straight from suture to suture, and are very regular. They are crossed by narrow elevated spirals, which are increased by the intercalation of secondary ones in the last portion of the ribbed spire. The ribs disappear at the beginning of the fifth

volution and there are four or five ribless whorls with faint raised spiral lines of primary and secondary type.

The very slight depression of the suture gives this shell a *Pleurotoma*-like aspect. The end of the canal is slightly reflexed.

The figure given by Petit shows only primary and secondary spirals, *i. e.*, a single intercalation of spirals in a large specimen of over eleven whorls.

Localities and Habitat: Coast of Gulf of Mexico (obtained by Captain Coue (Petit). Between Tampa and the Dry Tortugas in 27 fathoms on sand (Nat. Mus. 93654); Gulf of Mexico, in 26 fathoms on fine white sand (Nat. Mus. 83572).

FUSUS (?) DILECTUS A. Adams.

1855. *Fusus dilectus* A. Adams, Zool. Proc., 221.

1881. *Fusus dilectus* A. Adams, Tryon. Man. Conch., vol. III, p. 68 and 227, pl. 85, fig. 590.

A dead specimen in the collection of the National Museum with barnacles growing on its outer lip has been identified with the above species. It has the same aspect as the preceding, but differs in detail. It is somewhat stouter and less tapering. The protoconch is similar. The first whorl of the conch is worn, but appears not unlike that of the preceding species. The second third and fourth whorls have three strong sharp spirals in the center of the whorl, and an additional one on either side close to the suture. Intercalation of spirals occurs on both sides of the central spirals, and soon becomes compound. The ribs disappear in the later whorls, but the striæ continue. The shoulder is more concave than in *F. couei* and the center of the whorl has a more angulated appearance. The secondary and even the tertiary spirals become strong, and all are cancellated by the strong lines of growth, much as in *F. halistreptus*.

This species may represent a parallel to *F. couei* from another *Fusus* stock. The specific identification is doubtful.

Locality: Moluccas (Nat. Mus. 19314).

FUSUS CERAMIDUS Dall.

1889. *Fusus ceramidus* Dall, Blake Moll., vol. 2, p. 171.

This is not a typical *Fusus,* as its form is rather short with a short anterior canal. In this respect it comes nearest to the Mediterranean species of to-day.

The protoconch is typically Fusoid, the apical portion obliquely elevated, the last portion with fine riblets and ending in a varix. The first two whorls of the conch are non-angular, although two central strong spirals are present. Beyond this the whorls become angulated. The ribs are far apart and sharply angulated by two spirals; the third

is covered by the suture. There are two or three finer spirals on the shoulder. Intercalated spirals appear between these on the third whorl. In the next whorl the ribs become mere swollen undulations and the angularity is lost, while the shoulder changes from a flat to a convex contour. The whorls then become round and regular save for the imbricating subsutural band mentioned by Dall.

In one specimen a nodular character is shown on the center of the last two whorls, due to a strengthening of the two central spirals on the ribs and a complete obsolescense between them. The ribs are from two to three times their width apart.

Locality and Habitat: Blake sta. 273, 103 fathoms, Barbados (Nat. Mus. 87068) ; Blake sta. 290, 73 fathoms, Barbados (Nat. Mus. 87069).

The following species from the Blake collections must be referred to other, probably new, genera. *Fusus benthalis* Dall, *F. amiantus* Dall, *F. œpynotus* Dall; *F. alcimus* Dall (and variety) and *F. amphiurgus* Dall. They have for the most part a *Falsifusus* type of protoconch, and may be descended from that genus.

Species Not Seen.

The following additional recent species, probably referable to *Fusus,* were figured by Tryon (Man. Conch., vol. III), who for the most part refers them to species already noticed:

Plate 32, fig. 96, *F. brenchleyi* Baird (=*F. nicobaricus* var. Tryon).

Plate 34, fig. 112, *F. loebbechii* Kobelt (canal rather short for a true *Fusus*).

Plate 35, fig. 124, *F. hartwigi* Shuttlew (=*F. gradatus* Reeve (Tryon) ; fig. 125, *F. pacteli* Dunker (=*F. gradatus* Reeve, Tryon) ; fig. 126, *F. similis* Baird (=*F. undatus* Gmelin, Tryon) ; fig. 129, *F. leptorhynchus* Tapparone Canefri ; fig. 155, *F. pfeifferi* Phil. (Abbild. II, t. 3, fig. 1).

The following additional species are figured in Sowerby's Thesaurus Mon. Genus *Fusus.*

Plate 4, fig. 25, *F. sandvichensis* Sowerby, apparently allied to *F. toreuma;* fig. 28, *F. subquadratus* Sowerby; fig. 30, *F. acuticostatus* Sowerby (*F. coelatus* Reeve, Tryon).

Plate 5, fig. 35, *F. nodicinctus* A. Adams; fig. 36, *F. dilectus* A. Adams; fig. 37, *F. spiralis* A. Adams; fig. 38, *F. pateli* Dunker; fig. 43, *F. tasmanicnsis* Adams; fig. 44, *F. similis* Baird.

Plate 7, fig. 62, *F. graciliformis* Sowerby; fig. 66, *F. articulatus.*

Plate 8, fig. 77, *F. percyanus* Sowerby; fig. 78, *F. assimilis* A. Adams.

Plate 13, fig. 157, *F. lævigatus* Sowerby; fig. 159, *F. biangulatus* Deshayes; fig. 164, *F. rudicostatus* Sowerby; fig. 166, *F. lætus* Sowerby; fig. 168, *F. excavatus* Sowerby.

Additional Species.

Fusus strigatus Philippi, Abbildungen, vol. 3, p. 116; pl. V. (42), fig. 3.

Fusus pfeifferi Philippi, Abbildungen, vol. II, p. 117, pl. III, fig. 1.

Fusus nigricostatus E. A. Smith, Moll. from Japan, p. 202, pl. 20, fig. 33. Canal rather too short and flexed for a typical *Fusus*. Recalls *Aptyxis syracusanus*.

Fusus niponicus E. A. Smith, ibid., p. 203, pl. 20, fig. 3. Appears to be related to the *rostratus* series, if a true *Fusus*.

F. coreanicus E. A. Smith, ibid., p. 204, pl. 20, fig. 35. Probably not a true *Fusus*, may be related to the preceding.

Fusus pulchellus Philippi, Kobelt, Iconographie, p. 55, pl. 8, figs. 20 to 25. Appears to be related to *F. rostratus*. Canal too short and flexed for a typical *Fusus*.

The following additional species are figured by Reeve (Iconica, Fusus): Species 17, *F. aureus* Reeve, allied to *F. crebriliratus;* species 20, *F. ustulatus* Reeve; species 24, *F. torrulosus* Lam., allied to *F. distans;* species 52, *F. lanceola* (Martini) probably belongs to the *colus* series; species 54, *F. clausicaudatus* Hinds Voy. Sulphur, pl. 1, figs. 10, 11; species 58, *F. rufus* Reeve; species 65, *F. gradatus* Reeve; species 69, *F. gracilimus* Reeve, probably a member of the *colus* series; species 75, *F. acus* Adams and Reeve, a small form, probably of the *colus* series; species 88, *F. muricatus* Montagu, probably a member of the *F. rostratus* series.

Fossil Species Not Seen.

FUSUS (?) UNICARINATUS Desh.

1824. *Fusus unicarinatus* Desh., Coq. Foss. Env. Paris, t. 2, p. 515, pl. 72, figs. 11, 12.

1866. *Fusus unicarinatus* Desh., Anim. sans vert., t. 3, p. 252.

Not *Fusus unicarinatus* Beyrich, Zeitschrift der Deutsch. Geol. Gesellsch., 1856, p. 80, pl. 7, fig. 6.

1889. *Fusus unicarinatus* Cossmann, Cat. Coq. Foss., p. 177.

I have not seen this species, which occurs in the Sables inferieurs of the Paris Basin. I am inclined to class it with *Falsifusus? serratus* (Deshayes) though I am not unmindful of the possibility that it may prove a true *Fusus*. This, however, I doubt very much, for, occurring in the lower Eocene, it has already advanced beyond the Fusi of the middle Eocene (*F. aciculatus* of the Galcaire gross.) in development. The middle Eocene species are very primitive, while this lower Eocene species takes rank in development with Miocene and later species of true *Fusus* (*F. rostratus* and *F. bredæ*). The relationship must be established by the study of the protoconch, which I believe will show its relationship to *Falsifusus* rather than to *Fusus*.

Localities: Retheuil, Soissons, Cuise-Lamotte, Cuise St. Gobain, Paris Basin.

Horizon: Sables inferieurs. Lower Eocene.

FUSUS MULTISPIRATUS v. Koenen.

1856. *Fusus unicarinatus* Beyrich, Zeitschrift d. Deutsch. Geol. Gesellsch., p. 80, pl. VII, fig. 6.

1889. *Fusus multispiratus* v. Koenen, Nord-deutsch. Unter Oligocän, Lief. 1, p. 174, pl. 14, fig. 56.

Von Koenen describes the protoconch of this species as consisting of one and a half smooth swollen and strongly arched volutions, the apex "abweichend gewunden und eingewickelt." In the absence of illustrations it is somewhat difficult to understand the exact meaning of these words but they suggest the typical *Fusus* protoconch. The smooth portion is succeeded by a half volution which is ribbed with eight fine riblets. The protoconch is said to be similar to, though smaller than, that of the French specimens (*F. unicarinatus?*) from Cuise.

The sculpture of the conch appears abruptly, consisting of four strong spirals, the third of which (from above) is the strongest. The earliest whorls are round, and the ribs extend from suture to suture. The whorls later on become angular, the shoulder flattened, and the ribs obsolescent at the sutures. The central spiral forms a carina, which is strongly noded where crossed by the ribs.

Localities: Biere; Unseburg; Lattorf; Lethen; North Germany.

Horizon: Lower Oligocene (von Koenen).

This appears to be a true *Fusus,* representing the *torcumus* type of the modern series among the earlier Tertiary.

FUSUS ERECTUS von. Koenen.

1889. *Fusus erectus* v. Koenen, Norddeutsch Unteroligocän, Lief. I, p. 176, pl. 14, figs. *7a, b; 8a, b, c.*

This small species appears to be a true *Fusus* judging from the description. The protoconch is described as smooth and "blasig aufgetrieben" of one volution and a half, followed by a quarter volution with four smooth riblets. The ornamentation of the conch appears abruptly, with three spirals on the rounded whorl, the central spiral being the strongest. Additional spirals appear a little later, and intercalation occurs in the adult. Ribs strong and far apart in the adult; interspaces two to three times their width. The whorls remain round to the end.

Von Koenen compares this species with a variety of *F. aciculatus* from Mouchy.

Localities: Lattorf; Calbe; Atzendorf; Unseburg; North Germany (von Koenen).

Horizon: Lower Oligocene.

If this species is not the young of some more highly developed type, it probably represents a scarcely modified successor of the Eocene *F. aciculatus* (probably the British variety); and it may in turn have become the ancestor of the American progenitor (?) of *F. turriculus* and *F. cucosmius, i. e., F. hennickeni* of the Upper Oligocene (?) of the West Indies.

The other "Fusi" from the Oligocene of North Germany belong to other genera.

FUSUS INCONSTANS Michelin.

1831. *Fusus inconstans* MICHELIN, Mag. de Conchyliologie, p. 33, fig. 33.

This is a Fusoid shell with the earliest whorls plicated, but the last three smooth. The inner border of the lip is lirate, and the canal slightly flexed. A rather strong posterior canal is indicated.

Horizon and Locality: "Falunieres de Salles près Bordeaux (Michelin).

FUSUS PREVOSTI Partsch.

1856. *Fusus prevosti* PARTSCH, Hoernes, Foss. Moll. Tert. Beck. Wien, I, p. 285, pl. 31, fig. 9.

This species, found at Baden, Voslau Steinabrunn and other localities in the Vienna Basin, may be a ture *Fusus,* but its relations are not readily determinable from an inspection of the figure and from the description. Hörnes compares it with *F. longissimus,* to which his figure has some resemblance. R. Hoernes and Auinger (Gast. Oestreich Ungarn, p. 253, pl. 31, fig. 1) state that the figure and description are incorrect and give figures of a form with much shorter anterior canal. This makes this shell less like a true *Fusus,* and more like a *Fasciolaria,* to which genus it may belong.

B. SPECIES OF FUSOID SHELLS GENERALLY REFERRED TO FUSUS.

12. THE GENUS **APTYXIS Troshel.**

(1868. TROSCHEL, Das Gebiss der Schnecken, vol. 2, p. 64.)

This genus was founded for the reception of *Fusus syracusanus* L. It was supposed to differ from the true Fusi in the Fasciolarioid character of the dentition. Typical species of *Fusus,* however, such as *F. inconstans* and *F. australis,* have a very similar dentition. Nevertheless *F. syracusanus* differs sufficiently from typical species of *Fusus,* to demand a separate generic designation. The most important points of distinction are the short, slightly sinuous anterior canal, and the long stout spire. The protoconch and early stages appear to be like those of *Fusus.*

APTYXIS PROVENCALIS (Risso).

1824. *Fusus provencalis* Risso, Hist. Nat. L'Europe Mer., T. 4, p. 207, pl. 9, fig. 131.

1825. *Fusus provencialis* de Blainville, Fauna Française, Moll., p. 87, pl. 4D, fig. 1.

No specimens of this species have been seen, but the illustrations given by Risso and de Blainville show clearly the characteristics of this species. It appears to be a primitive Fusoid with simple ribs and spirals, the latter only in primary series. No angulation or keel appears, and the ribs continue to the lip. The canal is short and slightly flexed, corresponding to that of *A. syracusanus,* to which this species probably has ancestral relations. This relation was pointed out by de Blainville.

Accepting this relationship, the suggestion presents itself that this species is the connecting link between *A. syracusanus* and primitive members of the *F. rostratus* series of the same fauna. This relation may be tentatively maintained until more material can be studied.

Locality: Provence, Mediterranean coast of France.

APTYXIS SYRACUSANUS (Linnæus).

1767. *Murex syracusanus* Linnæus, Syst. Nat., ed. 12, t. 1, pt. 2, p. 12.

1847. *Fusus syracusanus* Reeve, Iconica, pl. 3, sp. 10.

1868. *Latyrus* (*Aptyxis*) *syracusanus* Troschel, Gebiss der Schnecken, vol. 2, p. 64.

1883. *Fusus syracusanus* Kobelt, Europäische Meeresconchilien, 3, p. 50, pl. 9, figs. 3–5.

The protoconch of this species is not preserved in sufficient perfection in the specimens examined to allow accurate determination. It appears to be typically Fusoid.

The conch begins with rounded whorls which suggest *Fusus provencalis.* The ribs of the early stages are broad and relatively close together, being less than their width apart. They are not very strongly marked by the spirals which are best developed in the interspaces. These interspaces are deeply colored. Intercalated spirals usually appear with the angulation, which in the less accelerated individuals begins late. It is brought about by the increase in thickness of the two central spirals which at first are similar. Later, however, the upper one increases in strength, and the shoulder becomes slightly flattened. The ribs at the same time become fainter except at the center, where they form nodulations at the angle.

The angulation increases through flattening of the shoulder, and through a corresponding flattening of the sides of the whorl, thus producing a rigid angulation. The ribs continue across shoulder and body of the whorl.

The most advanced specimens are characterized, in addition, by

revolving color bands, which cross the shoulder but leave practically the whole of the exposed part of the body free. This is as broad as the flat part of the body. Just above the suture the body recedes and is colored by several brown revolving bands. The ribs are most strongly developed on the white band.

In slightly more advanced specimens the same coloration occurs, but the nodulations on the shoulder angles become very prominent and the ribs weaker on the shoulder. Intercalation is twice compound. One specimen (M. C. Z. 931) shows a rerounding of the shoulders in the last two whorls, the shoulder on all the whorls being less flat. At the beginning of the ultimate whorls the ribs have disappeared, and the shell is smooth for about half an inch in length. This is apparently a pathologic condition. After this the normal conditions appear again, but with a convex shoulder which merges with the body more and more, so as to produce a uniform curvature. The angulation remains only as a carina. The revolving color bands do not occur in this specimen, but in their place vertical color bands mark the ribs slightly in front of the center from the beginning of the angulation to the end of the shell.

In another specimen (M. C. Z. 929) old age characters are shown, the ribs and shoulders having disappeared together with the color bands. The whorls at the same time become round and colorless.

Localities: Mediterranean (M. C. Z. 928, 930, 931, 932) (B. S. 229, 6083, 6084, 231); Tuscany (M. C. Z. 929); Morocco (M. C. Z. 933).

13. EOCENE SPECIES GENERALLY REFERRED TO FUSUS.

In the Eocene of the Gulf States of North America occur several species of Fusoid shells which have all the aspect of a true *Fusus,* but differ from that genus in the strikingly distinct protoconch. This is closely similar to that of many species generally referred to *Pleurotoma.* These shells are genetically related to *Levifusus,* and species like *"Fusus" bellus* of the same geological horizon which have similar protoconchs. Of these groups they represent the elongated types. Their genetic relation to certain species of the heterogeneous group *Pleurotoma* is suggested by the close similarity of protoconch and early whorls. For such shells with *Fusus* form and *Pleurotoma* protoconch the name *Falsifusus* is proposed.

FALSIFUSUS gen. nov.

Shells fusiform, with a long and slender spire, and a canal of about the same length. Protoconch merging into the whorls of the conch, no sharp line of demarkation being apparent. The first two whorls

of the protoconch are generally smooth, the apical one minute, gradually increasing in size. The three to four whorls which constitute the apical series form a rather narrow cone. Third whorl with fine closely crowded, more or less oblique riblets, which in part are gently concave forward. These, after the completion of the third, or sometimes an additional whorl, quickly merge into the normal whorls of the conch. A basal carina usually marks the ribbed whorls of the apical series, this carina appearing just above the suture. Whorls of the conch as in *Fusus*.

Type: Fusus meyeri Aldrich (= *F. ottonis* Aldrich).

FALSIFUSUS MEYERI (Aldrich).

(Plate XVII, fig. 9.)

1886. *Fusus meyeri* Aldrich, Bull. I Geol. Surv. Alabama, p. 21, pl. 3, fig. 12.
1896. *Fusus meyeri* var. Harris, Bull. Am. Pal., vol. I, p. 201, pl. 18, fig. 12 (see fig. 5).
1897. *Fusus ottonis* Aldrich, Bull. Am. Pal., vol. II, p. 172.
1899. *Fusus ottonis* Harris, Bull. Am. Pal., vol. III, p. 42, pl. 5, fig. 5 (see fig. 4).

(Since the present species is not a *Fusus* and Dunker's *Fusus meyeri* is, the original name may be retained and *Fusus ottonis* becomes a synonym for *Falsifusus meyeri*.)

The protoconch of this species is at first minute, but gradually and uniformly increases in size, the form being pyramidal. The first two whorls are smooth; the succeeding ones ornamented with strong sharply marked distant sublunate riblets, which are concave forward and at the same time gently slope forward. Just above the suture is a well-marked basal carina. The fourth whorl is somewhat more bulging than the preceding. No sharp line of demarkation occurs between this whorl and that bearing the normal ornamentation of the conch. The spirals appear abruptly, and with their appearance the whorls become angular. Above the central carinated spiral on the flattened shoulder occur three fainter subequal and subequidistant ones. A fourth appears next to the suture, on the sixth whorl from that on which the spirals first appeared, or the tenth from the apex. This spiral remains small and close to the suture. Below the central carina, two spirals of the body of the shell are shown. The second of these is just above the suture of the succeeding whorl, and is often somewhat strengthened, suggesting the double carination characteristic of many species of *Leucifusus*. A rather wide space separates this spiral from those below, which

Fig. 4. *Falsifusus meyeri* Lignitic type. (After Harris.)

are somewhat finer, and are to be considered as belonging to the spindle. The ribs throughout are rounded, and usually distant more than their width. In the later whorls they become obsolete towards both sutures. Harris figures a specimen (Bull. Am Pal., I, pl. 18, fig. 12) from near Oakhill, Alabama, of the variety designated by him as the "Matthews' Landing-Oak Hill type." in which the third spiral below the carina is strengthened, this spiral being just below the edge of the succeeding whorls. Intercalation occurs between the primary spirals of the spindle (fig. 5).

Fig. 5. *Falsifusus meyeri*, Midway variety.

The variety here described characterizes the lowest Eocene or Midway stage of the Gulf States. It differs in some respects from the type of the species as figured and described by Aldrich, and later refigured by Harris (fig. 4). The chief differences are, according to Harris: the greater number of costæ on some of the whorls in the Midway variety where they number as high as eighteen, while in the Lignitic variety seven or eight is the usual number; and the absence of the second incipient carination at the suture in the Lignitic variety, this being a marked feature in the Midway variety from Matthews' Landing.

Localities: Alabama Woods Bluff, Matthews Landing, Oak Hill, Dale Branch.

Horizon: Lower Eocene, Midwayan and Chickasawan groups.

FALSIFUSUS LUDOVICIANUS (Johnson).

(Plate XVIII, fig. 1.)

1899. *Fusus ludovicianus* Johnson, Proc. Phil. Acad., p. 72, pl. 4, fig. 5.

The protoconch of this species agrees in essential characters with that of *F. meyeri.* The first two whorls are smooth and gradually increase in size. The next whorl is marked by oblique narrow smooth riblets essentially as in *F. meyeri.* This is followed by the normally round-ribbed and spirally marked whorls, which with but slight modification continue to the adult stage. The shoulder is slightly flattened, but there is no pronounced angulation or carination of the whorl. It is, however, more bulging in the center than is normal in rounded-whorled species of Fusoid shells.

Fig. 6. *Falsifusus ludovicianus.* (After Johnson.)

Locality: Louisiana, St. Maurice Winn Parish (Johnson); Phil. Acad. — (U. S. Nat. Mus. 147226).

Horizon: Eocene, Lower Claiborne.

FALSIFUSUS (?) HOUSTONENSIS (Johnson).

1899. *Fusus houstonensis* Johnson, Proc. Phil. Acad. Sci., p. 72, pl. 1, fig. 4.

The apex of the only specimen of this species known is imperfect, and hence the precise generic position is not known. It may be a true *Falsifusus*, though judging from the similarity of the shell in the characters of the whorls to *"Fusus" apicalis* Johnson, it is not unlikely that these two species may be generically related to each other, while they may prove sufficiently distinct from *Falsifusus* to demand a separate generic designation.

The whorls of the adult shell are uniformly rounded, with round and strong ribs which reach from suture to suture, and are separated by strong interspaces. The spirals are simple except in the last whorl, where intercalations appear between the three primary spirals. No carination occurs, the whorls being throughout round. Johnson, however, states that the whorls are somewhat angular near the apex.

Fig. 7. *Falsifusus (?) houstonensis.* (After Johnson.)

If this species proves to be congeneric with *F. meyeri* we have a case of a species less specialized appearing in time after a more highly specialized one. For in *F. (?) houstonensis* the primitive feature of round whorls and round continuous ribs, with spirals mostly simple still persist, while in *F. meyeri* that stage is long past, although it appears earlier in the Eocene than does *F.? houstonensis.* If, on the other hand, this species and *"Fusus" apicalis* are congeneric as appears to be the case, then we can explain the apparent anomaly on the supposition that these two species represent a lateral branch from *Falsifusus*, in which the apical whorls are more accelerated, and the conch more retarded than in *F. meyeri.*

Locality: Alabama Bluff, Trinity River, Houston County, Texas.

Horizon: Lower Claiborne.

FALSIFUSUS (?) APICALIS (Johnson).

(Plate XVIII, fig. 2.)

1899. *Fusus apicalis* Johnson, Proc. Phil. Acad. Nat. Sci., p. 71, pl. 1, fig. 3.

This species is referred to *Falsifusus* with considerable reservation. Its apical whorls are so much further advanced than those of *Falsifusus meyeri* and similar species that a generic separation seems very desirable. Nevertheless it may be best to regard this species and the preceding one with it, if it prove of the same type, as a highly accelerated lateral branch from *F. meyeri.*

Apical whorls accelerated. The first smooth, the succeeding three with fine oblique and slightly concave, smooth and closely crowded riblets, which at the end of the fourth volution quickly give way to the

FIG. 8. *Falsifusus? apicalis.* (After Johnson.)

coarse rounded ribs cancellated by simple spirals which characterize all the succeeding stages. These ribs are separated by interspaces which are not infrequently twice the width of the ribs. The spirals are simple, but between the ribs and on the spindle they are nodulose. The aperture is somewhat contracted, and the interior of the whorl is lirate. The spindle is relatively shorter than in typical *Falsifusus,* thus giving the shell something of a *Latirus*-like appearance.

The protoconch of this species resembles somewhat that of *Pyropsis perula* Aldrich from the Midway beds of Matthews' landing.

Locality: Alabama Bluff, Trinity River, Houston County, Texas (Johnson, Phil. Acad. 6878).

Horizon: Eocene, Lower Claiborne.

FALSIFUSUS (?) SERRATUS (Deshayes).

(Plate I, figs. 9, 10, 14.)

1824. *Fusus serratus* DESHAYES, Coq. Foss. Env. Paris, t. 2, p. 515, pl. 75, figs. 12, 13.

1866. *Fusus serratus* DESHAYES, Anim. sans vert., p. 253.

1889. *Fusus serratus* COSSMANN, Cat. Coq. Foss., p. 178.

The protoconch of this species consists of several volutions and merges into the conch without any definite line of demarkation. There are in all nearly two smooth volutions, the first being swollen but depressed, with the apex buried in the succeeding whorl. It gradually increases in size, this increase continuing into the second whorl. On the lower part of the second whorl, above the suture, a sharp strongly-marked revolving line or spiral occurs, which lies just above the suture. After a volution or more it disappears. On the third whorl faint costæ or riblets occur above this line. These are smooth and not cancellated by revolving spirals. They are slightly concave forward, at the same time they slope obliquely forward from the upper to the lower suture. Towards the end of the third volution these ribs or costæ become stronger and more vertical, and finally they become cancellated by revolving spirals. The whorls up to this point are rounded.

It is very difficult to state in this case where the protoconch stops and the conch begins. In a few specimens a faint growth line appears after the first volution or volution and a fourth. This may mark the end of the protoconch, which in that case is smooth and without ornamentations. If this is the case the nepionic stage of the shell is characterized at first by a smooth half whorl or more, followed by a portion of a whorl with simple ribs, and later by the normal round-ribbed whorls with well-developed spirals. It seems best on the whole to regard this unusual type of ornamentation as belonging to the

protoconch stage, which may then be considered as highly accelerated as that of *Fusus*.

As the shell grows older the shoulder above the central spiral gradually becomes flattened, the angulation grows more pronounced, and finally flattened spines take the place of the simple carina. The ribs at the same time gradually become obsolete below the shoulder angle, and later on upon the shoulder as well. Slight undulations, however, mark the places where the ribs would cross the carina, and on these the flattened spines are prominent. The shoulder is marked by three strong spirals with interspaces decreasing in width towards the suture. Sometimes two additional finer spirals crowded close to the suture and near together occur on the adult shell. Only two spirals of the body of the whorl are visible above the suture, and in some cases the lower of these is covered up by the edge of the succeeding whorl, leaving only one visible. This latter with the central spiral developed into a carina, and with the first spiral above the carina constitutes the three primary spirals.

In the final portion of the last whorl of a large and probably gerontic individual of this species (pl. I, fig. 9) the spines of the angle become fused into a strong carinal ridge. The lines of growth at the same time become lamellose, and the aperture is slightly contracted.

Throughout the majority of the later whorls, *i. e.*, in both neanic and ephebic stages, the shoulder suddenly turns up below the suture, forming a narrow subsutural band and marking the early development of a posterior canal in the aperture. This feature, which does not generally occur in the Eocene Fusi, is an additional indication that this species in its own genus is further developed than are the Eocene Fusi.

The lines of growth of *F.* (*?*) *serratus* on leaving the suture are at first straight for the width of the subsutural band, then curve quite abruptly backward, and, after crossing the shoulder angle, curve again gently forward.

This species strikingly recalls *Fusus bredæ* Michelotti of the Italian Pliocene. It was apparently not until that later period in the Tertiary that true *Fusus* reached that stage of development which the present species had reached in the Eocene.

Localities: Parnes (M. C. Z. 1398, 27739); Epernay (M. C. Z. 1397) Paris (M. C. Z. 1399, 1405).

Horizon: Eocene, Calcaire Grossier.

The protoconch of this species differs to some extent from that of *F. meyeri*. The first whorl is like that of a true *Fusus* in some respects, while the second partakes of the nature of that of *F. meyeri*. It is most probable that the present species has originated entirely independently of the American Fusoid shells, probably from some Pleuro-

tomoid ancestor. If this is true, this species can not be referred to *Falsifusus,* but must be placed in a new genus.

FIG. 9. *Fulgurofusus quercollis.* (After Harris.)

FULGUROFUSUS gen. nov.

This is another of the pseudo-forms of *Fusus,* in which the outline and general characters are those of *Fusus* while the protoconch and early whorls are distinct. The protoconch is obliquely erect as in *Fulgur* and in *Levifusus (?) harrisi* Grabau from the lower Claiborne of Texas. (See Plate XVII, figs. 5, 6.) It does not end in a ribbed portion as in *Fusus,* but after barely one volution an angulation appears near the middle and with it a basal carina. This type of protoconch is identical with that of *Pleurotoma dimitiata* Brocchi and *P. coquandi* Bellardi, both of which are from the Italian Pliocene.

Genotype: Fusus quercollis Harris.

FULGUROFUSUS QUERCOLLIS (Harris).

(Plate XVII, fig. 6.)

1896. *Fusus quercollis* HARRIS, Bull. Am. Pal., vol. I, p. 200, pl. 18, fig. 9 (see fig. 9).

This species is well described by Harris and it is only necessary to add the following note to his description.

The protoconch is Fulguroid, consisting of one whorl which is smooth, obliquely erect and with a prominent apex.

The conch is not distinctly separated from the protoconch, and is very early marked by an angulation and a basal carina; *i. e.,* a strong spiral which appears just above the suture. The angulation is produced by two spirals which are crossed by vertically oblique semilunar riblets. The peripheral spirals are close together and at first equal, but later the upper one becomes more prominent and develops finally into the strong noduled keel so characteristic of the species. The lower spiral becomes fainter, and two others appear below it. None occur on the shoulder.

Locality: Graveyard Hill, Wilcox County, Alabama (Acad. Sci. 9019); Matthews' Landing, Alabama (Acad. Sci. 8524).

Horizon: Lower Eocene.

FULGUROFUSUS RUGATUS (Aldrich).

1886. *Fusus rugatus* ALDRICH, Bull. I Geol. Surv. Alabama, p. 22, pl. 5, fig. 9.
1896. *Fusus rugatus* HARRIS, Proc. Acad. Nat. Sci. Phil., p. 478, pl. 22, fig. 8.
1899. *Fusus rugatus* HARRIS, Bull. Am. Pal., vol. 3, p. 43, pl. 5, fig. 6 (see fig. 10).

This species has precisely the same type of protoconch as the preceding, but with the beginning of the conch only one spiral appears,

which is crossed by vertical ribs much after the manner of a young *Fulgur*. The ribs produce nodules where they cross the angulations. The adult whorls show a remarkable sinuosity or notch on the periphery, where this is marked with strong spirals. This notch is something over a fourth of an inch in depth, but becomes filled up later on and disappears as a notch from the margin. When the spine is developed at its maximum the notch extends outward from the aperture, but later on as the shell is built forward the notch comes to project backwards in the margin of the shell. This type of spine is precisely that found in adult *Fulgur*, such as *F. caricum*, and this together with the fulguroid protoconch of the present species suggests that we have in *Fulgurofusus* either the Eocene ancestor of *Fulgur* and *Sycotypus* or a closely related lateral branch from that ancestor.

FIG. 10. *Fulgurofusus rugatus*. (Aldrich.)

The Fusoid form of the species of *Fulgurofusus* is clearly a case of parallelism and is due to a great obliquity of whorls and a loose coiling. It is approached in certain species of *Fulgur*. From this same stock was undoubtedly derived the *Levifusus* series through such connecting form as *L. (?) harrisi* from the Texas Eocene.

Localities: Graveyard Hill, Wilcox County, Alabama (Acad. Sci. 9018); Gregg's Landing, Alabama (Acad. Sci. 6869).

Horizon: Eocene.

14. THE GENUS HEILPRINIA.

HEILPRINIA gen. nov.

This generic name is proposed for a number of recent and late Tertiary Fusoid shells from the Antillean region and Florida. They differ from *Fusus* in the very remarkable, strongly accelerated protoconch, which is throughout its greater portion crossed by riblets. (See detailed description under *H. caloosaënsis*.) The shells are usually close coiled with short spire and bulging whorls. The canal is long and the columella usually furnished with numerous short plications in the adult.

Genotype: Fusus caloosaënsis Heilprin.

HEILPRINIA CALOOSAËNSIS (Heilprin).

(Plate XVIII, fig. 5; Plate VIII, fig. 21.)

1887. *Fusus caloosaënsis* HEILPRIN, Trans. Wagn. Free Inst., vol. I, p. 68, pl. I, fig. 1.

1890. *Fusus caloosaënsis* DALL, Tert. Moll. Fla., pt. 1, p. 127.

1892. *Fusus caloosaënsis* DALL, ibid., pt. II, p. 234, pl. 14, fig. 3 (see fig. 11).

The protoconch in the specimens seen has a small rather pointed end, and is smooth for about a third of a volution. There is, however,

a slight hollow in the upper whorl of some specimens, as if a partial volution had been broken away. The smooth whorls are followed by whorls with narrow sharp riblets, which are close together on the upper part of the whorl, but separate towards the center until they are from two to four times their width apart, and then approach each other again towards the umbilical side of the whorl, their lower ends being hidden by the succeeding whorl. This type of riblets continues for about a third or a half volution, after which the riblets become concave forward, on the upper part of the volution and convex forward on the lower portion. The outline is something like a reversed letter S. The general slope of the riblets is downward and forward. After the completion of the first ribbed volution the riblets become more crowded, but the interspaces are of irregular width. Fine spiral lines make their appearance between the ribs, where they are hardly visible even with a magnifier. After the completion of over one and a half ribbed volutions of the protoconch the riblets merge into the ribs of the conch, there being no definite varix. Towards the end the ribs are vertical and subequally spaced. There appears to be a very fine barely visible spiral sculpture on the ribbed portion of the protoconch, traces of which have been seen throughout.

FIG. 11. *Heilprinia caloosaënsis.* (After Dall.)

The conch begins with whorls which almost from the outset show an angularity. This is due to the strengthening of the three central spirals, the middle one being strongest, while the lower one is covered by the edge of the succeeding whorl. The shoulder is flat and even gently concave, and has one spiral near the center and another just below the suture. The passage appears to be direct from protoconch to angulated whorl.

Not until the beginning of the fourth volution or sometimes much later is there any intercalation of spirals, and then only on the shoulder next to the suture band. Later, another spiral appears between this last one and the suture band. Intercalation also occurs between the lower of the three primary spirals and the spiral next below, but it is rarely observed on other parts of the shell. Very faint revolving lines may, however, be seen between most of the spirals.

The inner lip is not commonly developed to any extent except in adult individuals. On it is shown the influence of the spirals, producing pseudo-plications. There are also short horizontal plications which make a considerable angle with the former.

The general characters of the species have been so well described by Dall that they need not be given here. A remarkable specimen

of this species occurs in the collection of the U. S. National Museum (cat. 97494 pars.). The spire of this specimen is nearly turbinate, the sutures being hardly impressed. A strong vertical ribbon-like border marks the upper portion of the later whorls, and gives the shoulder a very concave aspect. The whole appearance of the shell is like that of some turbinate Pleurotomoids.

Localities: Caloosahatchie River, Florida (Nat. Mus. 97494); Shell Creek, Florida (Nat. Mus. 113220); Waccamaw River (Wagn. Free Inst.); Florida (M. C. Z. 27799).

Horizon: Pliocene.

HEILPRINIA CALOOSAENSIS var. CAROLINENSIS (Dall).

1892. *Fusus caloosaënsis* var. *carolinensis* DALL, Tert. Moll. Fla., pt. 2, p. 234, pl. 14, fig. 4*a* (see fig. 12).

1889. *Fusus caloosaënsis* var. *carolinensis* DALL, Blake Moll., pl. 29, fig. 4.

The type specimen of this variety shows an additional very minute half whorl or more on the protoconch, so that altogther there occurs a complete volution without riblets, but this portion of the protoconch is very small. This is followed by one and one half volutions, which is ribbed as described for the protoconch of *H. caloosaënsis*. The young conch appears bicarinate because the lower of the three spirals on each whorl is progressively covered by the succeeding whorl. The later whorls become more bulging and a strong secondary spiral appears between the middle and lower of the primary ones, the latter being barely visible above the suture. In some specimens the shoulder is less depressed, sloping flatly upward to the lower of the three spirals of the preceding whorl, resembling in this respect more the normal form. Intercalated spirals in these specimens do not appear until the final whorl.

FIG. 12. *Heilprinia caloosaënsis* var. *carolinensis*. (After Dall.)

This variety is stouter than the normal form of the species, and shows a slight advance upon it in that the ribs become obsolete much earlier. It apparently connects this species with *H. equalis*.

Localities: Tilly's Lake, South Carolina (Nat. Mus. 112349); Waccamaw, S. C. (Nat. Mus. 11455); Cape Fear (Nat. Mus. 8695).

Horizon: Pliocene, Waccamaw beds.

HEILPRINIA EQUALIS (Emmons).

1858. *Fusus equalis* EMMONS, Geol. Rep. North Carolina, p. 250, fig. 111.

1862. *Neptunea equalis* CONRAD, Proc. Acad. Nat. Sci. Phil., p. 560.

1890. *Fusus equalis* DALL, Tert. Moll. Fla., pt. 1, p. 126.

1892. *Fusus equalis* DALL, ibid., pt. 2, p. 234, pl. 14, fig. 3b.

The protoconch and young conch of this species and of *H. caloosaënsis* are almost absolutely identical. The early whorls are slightly less concave than in some specimens of *H. caloosaënsis* but more concave than in others. On the fourth whorl the ribs disappear and the spirals become fainter, the whorls at the same time changing from a subangular to a rounded contour. The fifth volution of this species is rounded while the same in *H. caloosaënsis* is still angular with strong spirals. Intercalated spirals appear in the third volution, and in the sixth and later volutions they have reached a uniform size with the primary ones and no new ones appear.

A very old specimen of this species has the spire somewhat elongated and the spirals are sharp, with very fine intercalated ones on the last whorl. The liræ of the inner lip and the posterior canal are of the type which occurs in *H. caloosaënsis,* the outline of the aperture being, however, more oval. The aperture of *H. caloosaënsis* is strongly contracted just below the body whorl.

For further description see reference given above.

Localities: Duplin County North Carolina (Nat. Mus. 112381); Magnolia, Duplin County, North Carolina (Nat. Mus. 114549, 114550, also at Wag. Free Inst.); Natural Well, Duplin County, North Carolina (Nat. Mus. 114548).

Horizon: Miocene (?) (If *H. caloosaënsis* is Pliocene, then *H. equalis* is probably not Miocene, and should normally occur with if not later than *H. caloosaënsis.* The Pliocene age of this latter species is accepted by all authorities.)

HEILPRINIA EXILIS (Conrad).

1832. *Fusus exilis* Conrad, Foss. shells Tert. Form. N. Am., p. 17, pl. 3, fig. 2.

This is another modification of the type of the genus. The protoconch has not been observed, but it is most probably of the same type as that of *H. caloosaënsis.* The shoulder in the earliest whorl observed is concave, with three strong spirals at the angle. The lower of these spirals is barely visible above the suture, the succeeding whorl covering its lower half. The first spiral on the shoulder next above the peripheral spirals is strong and sharp. The next one is weaker. This prominence of the first of the shoulder spirals gives the whorl a rounded appearance. This feature becomes more accentuated as the shell grows older. Ribs continue through five whorls, then quickly disappear and only strong, subequal and sharp spirals remain, between which are single finer ones. The primary spirals are about equal on the shell, there being seven and later eight of these between the sutures with intercalated secondary spirals between all. The outline of the aperture is more oval still than that of *H. equalis.* This latter species is intermediate between *H. exilis* and *H. caloosaënsis.* In *H. exilis* the aper-

ture and general form approach closely *Fusus closter* from the West Indies, except that the species is somewhat less stout. There is some variation, however, in the proportional length and slenderness of the spire in *H. exilis*.

The young of this species agrees well with *H. caloosaënsis*, while the later whorls are more advanced than any in that species. (Advance is not used here in the sense of progression, for the change is in reality a degeneration. There is, however, an advance along the path followed by these species in their development, both ontogenetic and phylogenetic.)

Locality: Alum Bluff, upper beds Florida (Nat. Mus. 97493).

Horizon: Miocene (Transition Oligocene to Miocene, Dall).

HEILPRINIA TIMESSA (Dall).

1889. *Fusus timessus* DALL, Blake Moll., vol. 2, p. 166.
1890. *Fusus timessus* DALL, Tert. Faun. Florida, pt. 1, pl. 7, fig. 6.

This shell in its spire agrees most closely with *H. exilis* from Alum Bluff (upper bed), Florida. It has, however, the contracted aperture in the adult, which marks the stout variety of *H. caloosaënsis*, but this is much less marked in the young. The protoconch is of the same type. It is solid, as shown by broken specimens. The bicarinate aspect of the early whorls is strongly marked from the beginning, owing to a covering up of the third spiral. The whorls have a somewhat more rounded aspect, as in the later stages of *H. exilis*. The ribs are strong, in some specimens even bulging. They die out toward the end of the fifth volution, after which there are only faint undulations. The spirals are very sharp; secondary spirals appear toward the end of the ribbed whorl.

The character of the sculpture of the adult is like that of *H. exilis*. An immature *H. timessus* superposed on an *H. exilis* of about the same age shows only a slightly more contracted lip in the former—the difference is not so great as is that between the two varieties of *H. caloosaënsis*.

H. exilis and not *H. caloosaënsis* appears to represent the ancestral form of *H. timessus*. The species has changed very slightly since the time of the Alum Bluff beds. The remarkable contraction near the beginning of the anterior canal, which is so like that of *H. caloosaënsis*, is in both cases probably a senile characteristic, as suggested to the writer by Dr. Dall.

Localities: Station 2316, Gulf of Mexico, 50 fathoms on coral, temp. 74 degr. Off Key West (U. S. Fish Com. Nat. Mus. 93652); Station 2134, 254 fathoms on sand, south of Cuba (Nat. Mus. 93653); Station 2404, Gulf of Mexico, 60 fathoms on sand, between Mississippi delta and Cedar Keys (Nat. Mus. 83495); Station 2411, Gulf of

Mexico, between Tampa and Tortugas, 27 fathoms on sand (Nat. Mus. 93651).

HEILPRINIA BURNSII (Dall).

1890. *Fusus burnsii* DALL, Tert. Moll. Fla., pt. 1, p. 126.

This species has the *H. exilis* type of whorl and sculpture, but is longer and more slender. The bicarination of the early whorls is marked. The shoulder is not so concave as in *H. exilis,* but the spirals and method of intercalation are similar. The fifth or sixth whorl of *H. exilis* has in general the character of the second to the fifth whorls of *H. burnsii.*

Locality: Petersburg, Va. (Nat. Mus. 97492).

Horizon: Miocene.

HEILPRINIA BARBARENSIS (Trask).

1855. *Fusus barbarensis* TRASK, Proc. Cal. Acad. Nat. Sci., vol. I, p. 41.
1903. *Fusus barbarensis* TRASK, ARNOLD, Pal. and Strat. San Pedro, Cal., p. 224, pl. IV, fig. 15.

The protoconch of this species is worn in nearly all the specimens seen, but in one the sculpture of *H. caloosaënsis* was noted. The riblets on the final portion of the protoconch merge into the ribs of the conch.

The conch shows three strong central spirals, the lower of which is just above the suture. Intercalated spirals appear on the fourth whorl of the conch. The angulation of the whorls is never very pronounced, and the canal is slightly deflected. In many individuals the last whorl or two are ribless.

This species agrees very closely with *H. burnsii,* which is slightly more angular, with thicker ribs and stronger central spirals. The intimate relation of these two can not be questioned.

Localities: Dead Man's Island, San Pedro; also various localities along the west coast of America (Nat. Mus. 124746); Santa Barbara (Trask).

Horizon: Pliocene.

HEILPRINIA ROBUSTA (Trask).

1855. *Fusus robustus* TRASK, Proc. Cal. Acad. Nat. Sci., vol. I, p. 41.
1903. *Fusus robustus* TRASK, ARNOLD, Pal. and Strat. San Pedro, Cal., p. 226.

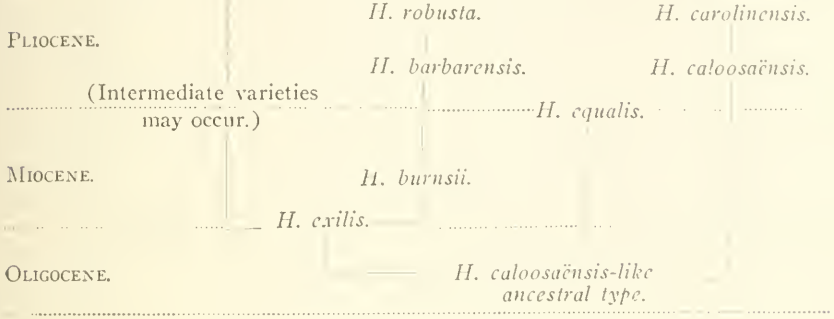
This species is like the preceding when young, but has a more flattened shoulder and more bulging whorls in the adult. The specimens are shorter and not so slender. It is clearly a descendant of the preceding species.

Locality: Fossil—San Pedro (Nat. Mus.); Recent—Santa Barbara, California (Nat. Mus. 7157, E. Jewett, 32399, Stearns coll.); Catalina Island (Nat. Mus. 32340, Stearns coll.).

Horizon: Pliocene to Recent.

Fusus rugosus Trask (Arnold), p. 226, pl. IV, fig. 7) appears to belong here.

If we accept the geologic horizon as given for these species,* we have great difficulty in arranging the species in their proper biologic as well as geologic relation. The following may serve as an attempt:



15. THE GENUS **EUTHRIOFUSUS** Cossmann.

This generic name was proposed by Cossmann (Paléoconchologie comparée 4me liv., p. 27, Oct., 1901) for *Fasciolaria burdigalensis* Basterot, a type which had been frequently referred to *Fusus*. I had previously used the generic name *Fusiolaria* in manuscript for this species, but Cossmann's name having been published has priority. The following generic diagnosis is new.

Fusiform shells with condensed spire which approaches that of *Fulgur*. The protoconch (pl. XVIII, fig. 16) is turbinate, consisting of about two smooth apical whorls, gradually increasing in size, followed by a whorl or more with strong oblique, slightly concave riblets. It gradually merges into the conch, in which the ribs are vertical and extend from suture to suture. An angulation appears in the first whorl of the conch, outlining a shoulder, which later on becomes concave from the development of a posterior canal and a corresponding subsutural band. Spirals numerous, crowded, intercalations appearing in the nepionic whorls. In the neanic whorls the ribs begin to disappear and are found as nodulations only on the periphery of the later whorls in most cases, though they sometimes persist throughout (in retarded species).

Genotype: Fasciolaria burdigalensis Basterot.

EUTHRIOFUSUS BURDIGALENSIS (Basterot).

(Plate VIII, figs. 1–8, 16, 20, 22; Plate XVIII, fig. 16.)

1820. Le Fuseau de Bordeaux De France, Dict. Sci. Nat., T. XVII, p. 541.
1825. *Fasciolaria burdigalensis* Basterot, Mem. Soc. d'hist. Nat. Paris, T. 2, p. 66, pl. VII, fig. 11.
1827. *Fasciolaria burdigalensis* Grateloup, Bull. Soc. Linn. Bord., T. II.

* See Dall, Table of Tertiary Horizons.

1840. *Fasciolaria* (*Fusus*) *burdigalensis* GRATELOUP, Conch Foss. Tert. L'Adour, pl. II, fig. 6, 7, 11.

1856. *Fusus burdigalensis* HÖRNES, Foss. Moll. Tert. Beck. Wien, p. 296, pl. 32, figs. 13, 14 (with bibliography).

1901. *Euthriofusus burdigalensis* COSSMAN, Ess. Pal. Comp. 4me liv., p. 28, pl. 1, fig. 1; text fig. 14.

Since De France applied only a French name to this species, merely listing it without description, he can not be considered the author of the specific name, as is generally done. Basterot's description and figure are the first published, and as he was the first to use the specific name he must be considered its author. Basterot's figure is of a specimen similar to that given in Plate VIII, fig. 6, and described below. The protoconch is of the type described under the genus.

Var. TUBERCULOSUS Grateloup (fig. 6).

(Plate VIII, figs. 1–3.)

"Anfract. ad suturas tuberculiferis" (Grateloup).

The following description applies only to the specimens figured, with others from the same locality. They appear to be referable to Grateloup's variety.

The early (nepionic) whorls of the conch are round with simple ribs extending from suture to suture, and crossed by spirals of moderate strength. In the smaller specimen figured there are nearly three volutions of this type. In the neanic stage the shoulder becomes flattened, and the peripheral angulation appears. This stage merges into the ephebic, in which the ribs become restricted to the body of the whorl, the shoulder remaining ribless and slightly concave in contour. The spirals have become faint on the adult portion of the shell. On the periphery the ribs cause a nodulation, but this is subdued.

Locality: Leognan, France (M. C. Z. 1321).

Horizon: Miocene.

This is the most primitive variety seen. It retains the simple ribbed character through the adult.

Var. CARINATUS var. nov.

(Plate VIII, figs. 4, 5.)

In this variety and in the succeeding ones the whorls are angular almost from the beginning, though the first whorls may show a subangular or almost rounded contour. The ribs cause a strong tuberculation at the periphery, and this, together with the flattened shoulder and the numerous spirals, gives the young shell a strong resemblance to *Fusus rostratus*. The ribs become obsolete in the fourth or fifth whorl, but the angulation continues in the form of a faint keel to the end. In the more primitive types the ribs persist as nodules on the keel, thus connecting this variety with the preceding one. Generally,

however, the nodules disappear after a while and the keel or carina alone remains. In old individuals the keel may disappear, this portion of the whorl having the characters of the typical form of the species.

Localities: This and the succeeding varieties are found in great abundance in the vicinity of Bordeaux, and in the Vienna Basin. The detailed localities are given below.

The Typical Form of the Species.

(Plate VIII, fig. 6; also figs. 7, 8.)

Basterot's original description is as follows:

"F. testa transverse presse lineolata, lineis inæqualibus; anfractibus superioribus solum plicatio, subtuberculatis."

In this form the keel is lost early, the last whorls of the conch being rounded in contour. In some specimens the keel is not at all developed, and the rounded whorls follow immediately upon the subangular ribbed whorls. Spirals are very numerous, increased by intercalation, which becomes prominent in the fifth whorl.

Var. MAJOR Grateloup (fig. 7).

(Plate VIII, fig. 22.)

"Anfract. carinatis ad medium subnodosis." (Grateloup.)

This variety is large and robust. Following the tuberculated stage a carina appears on which spines of moderate strength are formed. These are of the type found in *Fulgur carica,* though they are not so pronounced as in that species. Some of the specimens of this variety have a striking resemblance to species of *Fulgur* from the American Tertiary this resemblance being due, however, to parallelism and not to genetic relationship. These spines appear in some specimens after the disappearance of the tubercles, and the formation of the carina stage (Pl. VIII, fig. 8). They thus indicate a distinct line of development for this variety.

The relations of these varieties may be expressed as follows:

var. *major.* — *F. burdigalensis* (typical).

— var. *carinata.*

var. *tuberculosus.*

A form identical with Basterot's typical form was figured by Grateloup under the name var. *sublævigata* with the following description: "Testa minore fragile laevigata."

There is some variation in the slenderness of the species, but most individuals have a strongly convex or bulging body-whorl. All speci-

mens show a strongly lirate outer lip, a strong posterior canal, a pronounced transverse plication on the columella, just below the canal, and usually a faint oblique grove on the columella.

Localities: The localities given by Basterot for this species are Leognan, Saucats, and Merignac, France. In the following list the numbers refer to the collections of the Museum of Comparative Zoology.

Var. *tuberculosus* Leognan (M. C. Z. 1321); Dept. Landes (M. C. Z. 1323); Castel Arquato (?)* (M. C. Z. 1324); Cabannes-St. Paul, Dax (1329); Leognan et Saucats (27802).

Var. *carinatus* Bordeaux (1315, 1316); Paris Basin (?)* (1317, 1318); Leognan et Saucats (1319).

Typical form: Leognan et Saucats (1320, gerontic, 27801); Bordeaux (27803, 27804, also young 1322, accelerated, 1314).

Var. *major:* Steenabrunn, Vienna Basin (1327, 1328); Leognan et Saucats (27800).

Besides the varieties given above, the following have been named by Grateloup: var. *scabra, contorta, aspera, calcarata, plicata, dubia.*

Horizon: Miocene.

C. PHYLOGERONTIC FUSIDÆ.

15. THE GENUS **CYRTULUS Hinds.**

(1843. Hinds, Ann. and Mag. Nat. Hist., vol. XI, p. 256.)

This genus was made by Hinds for the reception of a remarkable gastropod shell found in the Pacific Islands. In its young stages this species is a typical *Fusus*, and might be classed with the *colus* series, with the species of which it agrees in all its general characteristics. The adult whorls, however, show a remarkable deviation from this slender Fusoid growth, consisting of thick irregular whorls, loosely wrapped about one another with a complete loss of shoulder, spirals, ribs and other surface features, and with a complete obliteration of the characteristic form of the young.

This type of structure, which may be designated melongenoid, from its characteristic occurrence in *Melongena melongena* and related species, is essentially an accentuated development of old age characteristics of the type found in normal Fusi in senescent individuals. In the present type it has become an established characteristic and from a gerontic feature has been pushed back to the ephebic and even the late neanic stage through the operation of the law of acceleration. Species of this genus, then, must be considered as phylogerontic Fusi, *i. e.*, species which are typical Fusi when young, but when adult are characterized by structural features found only in extreme old age individuals of the normal *Fusus* series.

It has become customary to unite this genus with the Eocene genus *Clavilithes* described earlier by Swainson. These two genera have,

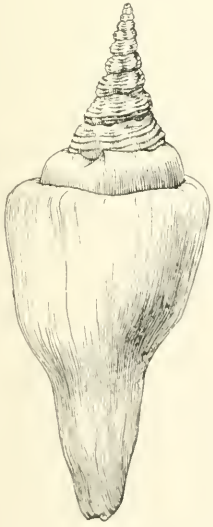
* Probably an error.

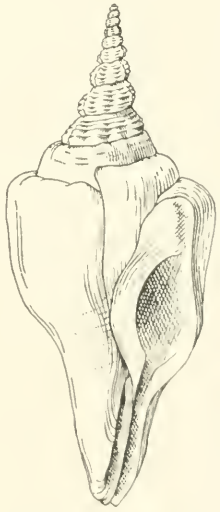
however, no genetic relation whatever, belonging to entirely distinct families of gastropods, and having only an external resemblance in their respective adult stages. This resemblance is often very close when the adult stages are alone considered, but the great differences are at once shown when the young are examined. This resemblance is simply a case of parallelism, in which features of the same type recur in corresponding stages of otherwise entirely distinct individuals. This is a case similar to the noncoiling of the Cretacic Ammonoids, where this feature recurred in a number of phylogerontic individuals belonging to entirely distinct genetic series. To class *Cyrtulus* and *Clavilithes* together is as great a mistake as to unite the genera *Macroscaphites* and *Ancyloceras* under the same generic name, simply because they are both partly uncoiled Ammonoids.

CYRTULUS SEROTINUS Hinds.

1843. *Cyrtulus serotinus* Hinds, Ann. Mag. Nat. Hist., vol. XI, p. 257.
1844. *Cyrtulus serotinus* Hinds, Zoöl. Voy. H. M. S. Sulphur, vol. 2, p. 13, pl. 1, figs. 12, 13.

The protoconch of this species has been fully preserved on only one of the specimens seen (Am. Mus. Nat. Hist.), though another specimen (Nat. Mus. 91755) and several others in the American Museum show the last portion. It is prominently developed, consisting





Figs. 13 and 14. *Cyrtulus serotinus*. Coll. Bost. Soc. Nat. Hist., 278.

of nearly two and a half volutions. It ends abruptly with a varix, and the normal round-whorled and ribbed type of *Fusus* conch begins as abruptly; the last whorl and a quarter of the protoconch are finely ribbed vertically as in *Fusus*, with which this portion agrees perfectly.

The initial whorl, however, is not so swollen and elevated as is usual in *Fusus,* but is rather depressed. In spite of this difference in the initial whorl the final portion of the protoconch and the early whorls of the conch are so typically of the *Fusus* type, that the derivation of *Cyrtulus* as represented by this species from *Fusus* can not be doubted.

It is to be noted that the ribs of the protoconch are more numerous than in *Fusus,* and are closely crowded. There is a suggestion of the *Falsifusus* type of protoconch in the apical part, but the second whorl is typically Fusoid.

The conch is at first indistinguishable from a young *Fusus* of the *colus* series. The whorls are round with rounded ribs separated by interspaces of about their own width. After seven or eight whorls of this type the *turriculus* stage comes to an end, being slowly replaced by the *torcumus* stage. The shoulder angle it at first barely defined, being indicated by the prominence of two central spirals. At this stage intercalated spirals first appear. The shoulder angle gradually becomes more distinctly defined, thus fully establishing the *torcumus* stage. With this the spirals become less sharp, the ribs disappear and the whorls become irregular, the later added portions reaching up onto the earlier whorls. The angulation and the tubercles disappear, and the spirals become more and more obsolete. The whorl becomes smooth, thickened and enveloping. The posterior canal of the aperture, always a gerontic feature, becomes strong and causes a shelf or flattened shoulder on the upper portion of the whorl, next to the suture. The spindle becomes more enveloped, and its form obliterated as the ephebic whorls of this phylogerontic species are thickened. This results in the production of a melongenoid form. The aperture becomes elongate as in *Pyrula, Fulgar,* etc., and in extreme cases a tendency to uncoil and form an umbilicus is shown. This melongenoid portion of the shell is covered by a smooth brown periostracum. The preephebic whorls show the coloration of *Fusus.*

An old specimen (Nat. Mus. 130896) shows three whorls wrapped around each other on about the same plane.

Localities: Indo-Pacific (Nat. Mus. 130896, 91755, Dall); Pacific Islands (B. S. 278, also Mayo coll.); Nonkahiva, Marquesas group, S. Pacific (M. C. Z. 964, 963, Am. Mus. Nat. Hist., numerous specimens).

Habitat: In nine fathoms among sand, Hinds (Tryon).

15. THE EOCENE CLAVILITHOIDS.

Under this heading will be described the various species of Eocene Fusoid shells which have assumed a melongenoid growth and are comparable to *Cyrtulus* or *Clavilithes,* with which latter they are generally classed.

CLAVELLOFUSUS gen. nov.

The species of this genus are generally placed under *Clavilithes,* and all of them are united with *Clavilithes parisiensis* (Mayer-Eymar) (=*C. deformis* (Solander) Cossmann) which is the *C. longævus* (Lamarck not Solander) of most authors. Even so high an authority as Mons. Cossmann refers all the species of this genus to that one species of a genus which, though related to the present one, is nevertheless quite distinct.

The genus is characterized by the long slender spire, the whorls of which in the more primitive species rest upon each other in the manner of the slender Fusi. The ribs are strong and far apart, and the protoconch consists of not more than two and a half volutions, the last one of which is sparingly ribbed and the first obliquely erect as in *Fusus.* The whole protoconch is minute and markedly different from the coarse many-whorled protoconch of *Clavilithes* with its depressed "naticoid" apical whorl. The sutural shelf is abrupt in this genus, delimited by a sharp angle, and either horizontal or sloping slightly inward. The shell has considerable resemblance to the recent *Cyrtulus,* but differs from that genus in the character of the young conch as well as in the details of the protoconch. Finally *Cyrtulus,* the modern fuso-melongenoid, is a direct descendant of the modern Fusi, while *Clavellofusus,* the Eocene fuso-melongenoid, appears to be a descendant of the Eocene Fusi, and is unknown outside of the Paris Basin.

Genotype: Clavellofusus spiratus sp. nov.

CLAVELLOFUSUS SPIRATUS sp. nov.

(Type Plate I, fig. 23; see also Plate I, figs. 17, 20 and 26; Plate XVIII, fig. 4.)

The protoconch of this species has only been seen in two specimens, in only one of which (Acad. Sci. 8024, Plate XVIII, fig. 4) it was completely preserved. It is minute and Fusoid in its apical portion, but consists of about two and a half volutions, a character never found in *Fusus,* but characteristic of *Cyrtulus.* The second whorl is scarcely larger than the first, and in the last portion is marked by faint vertical riblets which are very obscure in the specimen illustrated, but in a specimen in the collection of the Museum of Comparative Zoölogy (1099) these vertical riblets are better shown though still faint. They are thin and smooth. There is no final varix, but the protoconch stops abruptly and the ribbed conch begins as abruptly. In one specimen (M. C. Z. 1097) faint revolving spirals are shown on what appears to be the final portion of the protoconch: these cease abruptly and the coarse-ribbed conch begins as abruptly. The protoconch appears to be umbilicated, the umbilicus disappearing on the completion of the protoconch. In the illustrated specimen a few strong vertical riblets occur toward the end of the protoconch. They are rather distant and are followed by the

ribs of the conch. The protoconch of this genus, therefore, combines the characters of *Fusus* and *Clavilithes*, and this, together with the characters of the conch, indicates that *Clavellofusus* occupies a position intermediate between *Fusus* and *Clavilithes*.

The conch begins with nearly uniformly rounded whorls, with equal and uniform ribs, which, however, quickly become swollen in the center, and then die out towards the suture. They are widely separate and crossed by uniform spirals. In some cases the ribs are separated by interspaces equal to three or four times their own width, and the spirals generally show a perfect gradation in thickness and in spacing, from the periphery to the sutures. Intercalated spirals appear in about the fifth or sixth volution.

All the whorls of the early stage are globular, and embrace about a fourth of the preceding whorl. The spire is, therefore, much more elongated and slender than in species of *Clavilithes*.

In the early neanic the ribs change from a definite sharp and distinct outline to an ill-defined one, becoming more of the nature of undulatory wrinkles. In the later neanic they become obsolete, as do also the spirals. Intercalation begins in the late neanic, seldom earlier.

The ephebic whorls are globular at first, and free from ribs or spirals. A very faint shelf is developed next to the suture which gradually grows broader. This shelf is caused by the development of a deep and strong posterior canal, and it is accentuated by the slight convexity of the later whorls, by their strong embracing of the preceding whorls up to or beyond the middle and by the consequent slight depression of the suture.

In the met-ephebic stage the whorls have changed from a rounded to a cylindrical form, the sides of the whorl becoming parallel to the longitudinal axis of the shell. This gives the shell a rigid appearance which is very marked. The sutural shelf is very pronounced at this stage. It is sharply delimited at the margin, and makes a right angle or something less with the outer face of the shell. It slopes slightly inward from the sharp shoulder angle. This species may be compared with accelerated individuals of *Clavilithes parisiensis*, in which the sutural shelf appears in the *conjunctus* stage. Except for the long spire, it could be considered a parallel to *Clavilithes subscalaris*. The distinctive generic characters allow, however, ready separation.

Injured and gerontic individuals show a decrease in the size of the aperture and a loss of the characteristic sutural terrace or shelf. In such individuals the inner lip also separates from the columella, thus showing a contraction of the aperture on all sides.

The specimen illustrated in fig. 20, pl. 1, is somewhat more accelerated than the typical forms. The stage with round whorls and

shelf is short, the whorls quickly becoming cylindrical. In this respect this shell approaches *Clavellofusus macrospiratus*. Fig. 16, pl. I, is a young shell of *Clavellofusus*, still in the ribbed (*Fusus*) stage, which may belong to this species.

Localities: Paris Basin (M. C. Z. 27731, 1098); Soissons (M. C. Z. 1099, 1100); Chaumery (M. C. Z. 27746); Cuise Lamotte (M. C. Z. 27750); Montmiraille (M. C. Z. 27785); Comprigne (M. C. Z. 1096, Type).

Horizon: Lower Eocene.

CLAVELLOFUSUS TUBERCULATUS sp. nov.

(Type Plate I, fig. 19.)

(See also figs. 18 and 22, Plate I.)

This species is less accelerated than the preceding, which passes through the stage at which this species stops. The early stages are as described for *C. spiratus*, there being six or more of the ribbed whorls (counting those which are broken away). In the last two whorls before the shell becomes smooth the ribs gradually become obsolete, finally disappearing altogether. The spirals, however, continue for a time. This gives two short stages comparable to the *dameriacensis* and *conjunctus* stages in the *Clavilithes* series.

Thus, the penultimate whorl is free from ribs, but marked by spirals. It is rounded and is closely appressed to the preceding one, there being no sutural shelf. This may be compared to the *subconjunctus* stage. The spirals gradually become obsolete, the shell then being comparable to *Clavilithes conjunctus*. Before the complete disappearance of the spirals, the sutural shelf appears, which is characteristic of the last whorl, this retaining its convex contour, but being free from spirals. This is the adult stage of this species, judging from the size of the shell. It corresponds to the late neanic or early ephebic stage of *C. spiratus* which passes beyond in the adult stage, where it assumes a cylindrical form of whorl.

Specimen fig. 18 (pl. I) may represent a young of a somewhat accelerated individual of this species, though it is perfectly possible that it might in the adult have assumed a cylindrical whorl, and thus become a *C. spiratus*. The ribs become obsolete in about the sixth whorl, the spirals disappearing shortly after. The shelf appears shortly after the disappearance of the ribs, the contour of the whorl, however, remaining convex. The shell, therefore, is in the *tuberculatus* stage. Specimen fig. 22 is likewise in the *tuberculatus* stage, and judging from the strong convexity of the whorls probably represents an immature *Clavellofusus tuberculatus*. The shelf appears very soon after the disappearance of the ribs, the spirals becoming very faint on the ribless whorls. Fig. 18 is from Soissons, fig. 22 from Cuise.

This species corresponds to *Clavilithes tuberculosus* Desh., which in that series occupies the same stage in development.

Localities: The type specimen is from Cuise (M. C. Z. 27729); Soissons (M. C. Z. 27732).

Horizon: Lower Eocene.

CLAVELLOFUSUS MACROSPIRATUS sp. nov.

(Type Plate I, fig. 28.)

(See also Plate I, figs. 21, 24, 25 and 27.)

This species is the most accelerated of the group, paralleling the French *Clavilithes macrospira* Cossmann, or the British *C. solanderi* Grabau, of which these specimens seem at first sight to be diminutive representatives. The early stages are as in the other species of this genus, but the ribbed whorls are fewer in number. The last of this series of whorls lose their rotund character, the ribs at the same time changing into mere undulations. With the disappearance of the ribs, or even before this, the sutural shelf appears, the whorls at the same time becoming cylindrical. This implies a complete dropping out of the *tuberculatus* stage, *i. e.,* the stage characterizing the adult *Clavellofusus tuberculatus.* This stage generally occurs in unaccelarated species of this and other series, following the ribbed, and preceding the cylindrical-whorled stage. The present species appears, therefore, to be derived from *C. spiratus,* through a process of acceleration by elimination, the *tuberculatus* stage being eliminated.

The majority of the specimens of the genus which have been seen in the collections belong to this species, the group as a whole being strongly accelerated.

In fig. 25 of plate I is shown the young of the most accelerated individual of this series which has yet come under my observation. The ribbed stage is well developed, and while the whorls are still marked by coarse ribs, a sutural shelf appears. At first the whorls continue round, but soon they assume the cylindrical form with the sides parallel to the main axis of the shell. The ribs, however, continue, there being about a whorl and a half, which are furnished with a shelf and ribs at the same time. It might be considered that we have here a ribbed *tuberculatus* stage followed by a ribbed cylindrical or subconic stage.

This is, therefore, an example of an accelerated type, in which one feature (the shelf) has become excessively accelerated, appearing while some of the other primitive features are still retained. In the latter part of the ribbed and shelved whorls the shelf or terrace even projects slightly, suggesting the *scalaris* stage of the *Clavilithes* series (vide *C. scalaris*). There is some considerable variation in the number of ribbed whorls and the appearance of the sutural shelf. This is illustrated in the specimens figured on plate I.

This species occurs with the others of this genus at Cuise in the Paris Basin. It is commonly classed as a variety of *Clavilithes parisiensis* Mayer (= *C. deformis* (Sol.) Cossmann or *C. longævus* (Lamarck) of Deshayes and other authors).

Localities: Cuise (M. C. Z. 1097, 27730); Comprigne (M. C. Z. 27740).

Horizon: Lower Eocene.

Young specimens of this generic series can not generally be placed in the species to which they belong, since all the species have in young stages the characters of more primitive species of the series and assume their true specific characters only in the adult stage. Thus fig. 16 is in the ribbed stage, resembling the most primitive type of the series, of which, however, no representative has been found (unless the Eocene species of *Fusus* be considered such). Certainly if an adult specimen with the characters of fig. 16 were found, it would have to be placed near the true Fusi, since the protoconch and other characteristics of such a species would approach those of that genus. The ribs of the early whorls of *Clavellofusus* are more widely spaced than is the case with any species of *Fusus* I have seen, but this feature may occur in shells which otherwise conform to the characteristics of that genus. This stage then is the *Fusus* stage of the *Clavellofusus* series, just as the young of *Cyrtulus* represents the *Fusus* stage of that series, and clearly indicates the ancestry of that genus. In the *Clavilithes* series, this stage is represented by *C. rugosus*, and is there known as the *rugosus* stage. (For further discussion see beyond p. 105.)

In like manner it will be seen that specimen fig. 18 is in the *tuberculatus* stage, being comparable to an adult *C. tuberculatus* of this series, or an adult *C. tuberculosus* of the *Clavilithes* series. It may remain in this stage, simply increasing in size, or it may develop into a *C. spiratus* by adding a cylindrical whorl.

A constant and very characteristic feature of the species of this genus is the sharp angle between the sutural shelf, and the side of the whorl. This is particularly marked where the whorls have assumed the cylindrical habit of growth. The shelf generally slopes inward and downward, rather than upward as in *Clavilithes* of the Paris Basin, in which the angle is also more rounded. In this respect these shells are similar to *Clavilithes solanderi* Grabau of the English Eocene, in which the same type of shelf exists. The pointed apex and the small size of these shells are also distinguishing features.

Localities: The three species given above, together with intermediate forms, and probably other species, occur together in the Lower Eocene of the Paris Basin.

Horizon: Lower Eocene, Sables inférieurs, Paris Basin (Deshayes).

Synonymy: Fusus longævus var. A. Deshayes, Coq. Foss. env.

Paris, T. II, pl. 74, fig. 21. 1824. *Clavilithes longævus* Lam. var. of authors generally. *C. deformis* var. Cossmann.

THE GENUS **CLAVILITHES** Swainson.

This genus was instituted by Swainson in 1840,* as a substitute for *Clavella,* which he had established a few years earlier (1835†) for *Fusus longævus* Lamarck (Deshayes) (= *F. parisiensis* Mayer-Eymar) and allied types. The later generic name would not hold, were it not for the fact, apparently unknown to Swainson, that *Clavella* was used by Oken in 1815 for a crustacean. Swainson included *Fusus noæ* in his genus, a practice carried out by every subsequent writer. That species is, however, strikingly distinct from *F. longævus* of Lamarck and Deshayes, and is here separated under the generic name *Rhopalithes.* Swainson's description leaves no doubt as to which species belong to his genus, for he gives the characteristics of *F. longævus* (*F. parisiensis* May.) and not those of *F. noæ.*

The protoconch of this genus is very striking, and is distinctive, though there are other genera, apparently not very closely related to this genus, which have similar or perhaps even identical protoconchs. The first whorl of the protoconch is depressed and naticoid, with a minute apical portion. The whorl gradually enlarges, but after the first volution the proportional increase in size is much less, so that the whorls produce a nearly cylindrical protoconch. There are from two and a half to four whorls, thus giving the protoconch a distinctly papillose appearance. The protoconch is umbilicated and very generally contains from one to several septa. There is no final varix, and the line of separation between protoconch and conch can not generally be indicated. In some specimens (fig. 15) a sharp line marks a cessation of growth, but whether that is the end of the protoconch or merely a temporary interruption in the building of the protoconch is not clear. The fact that this line is not found in all specimens suggests that it is only an individual characteristic and does not necessary mark the end of the protoconch. This view is strengthened by the fact that similar lines occasionally occur on other parts of the protoconch, where they mark a slight interruption of growth. Sometimes a slightly wrinkled appearance is produced by these lines, which give a faintly ribbed aspect to the protoconch in places. A few simple smooth ribs occur before the normal ribs of the conch appear, and between these smooth ribs are generally to be found faint revolving lines. These do not, however, affect the ribs. It is a question difficult to answer whether this portion belongs to the protoconch or to the conch. As the change is not a very abrupt one we may assume that the embryonic stages

* Swainson, "Treatise on Malacology," p. 304, p. 90.

† Swainson, "Elements of Conchology."

merged gradually into the embryonic, and that hence no sharp line is to be drawn between the two. Judging from analogy with other fusoid shells we are, I believe, justified in relegating this portion with the primitive ribs to the protoconch.

The conch always begins with round whorls, which are ornamented by coarse widely separated ribs and by strong sharp spirals. This portion of the shell may be very short, and the ribs may become almost obsolete or the whole shell may consist of rounded, ribbed and spiralled whorls. This latter is the case in the primitive species, such as *C. rugosus*, which might well be separated generically from *Clavilithes*.

In the typical species of the genus the ribbed whorls are succeeded by smooth irregular whorls of the melongenoid type. These show progressive differentiation in the various species, according to the degree of acceleration characteristic of each.

The columella is without plaits.

The genus is confined to the Eocene.

Type: Clavilithes parisiensis (Mayer-Eymar), — *Clavilithes longævus* Lam. (Deshayes) non-Solander.

CLAVILITHES RUGOSUS (Lamarck). (Emend. Grabau.)

(Plate IX, figs. 1–8; also text fig. 15.)

1803. *Fugus rugosus* LAMARCK, Ann. du Mus., t. I, p. 316.
1816. *Fusus rugosus* LAMARCK, Tab. Encyc. Meth., pl. 425, fig. 6.
1823. *Fusus rugosus* LAMARCK, Coq. Foss. Env. Paris, p. 56 (pars).
1837. *Fusus rugosus* DESHAYES, Coq. Foss. Env. Paris, t. 2, p. 519 pars, pl. 75, figs. 4–7.
1889. *Clavilithes rugosus* COSSMANN, Cat. Coq. Foss. Eoc. Env. Paris, p. 174.

The protoconch of this species is papillose, the number of whorls varying from three to four. It is smooth throughout the earlier whorls, but marked in the final (?) portion of the last whorl by smooth narrow vertical riblets which are widely separated. At first the interspaces are smooth, but later revolving lines—the beginning of the spirals—appear, but these do not cross the riblets. The number of riblets varies from three to five.

The conch begins with rounded whorls with strong uniform rounded ribs which are rather narrow and separated by interspaces several times as wide as the ribs. They are crossed by strong sharp and uniform spirals of which from five to six are visible. After a volution or two the spirals in the center of the whorls become stronger and sharper, producing strong cusps at the crossing of the ribs. The latter become stronger, broader and less defined and a subsutural band appears, indicating the presence of a posterior canal.

In the adult the ribs are somewhat less distinctly defined and the subsutural band and posterior canal more profound. Intercalated

spirals sometimes appear, occurring at times even in pre-ephebic stages. The shoulder is somewhat flattened, and near the suture becomes slightly concave. The lines of growth are not infrequently strong and imbricating, strongly cancellating the spirals, which are sometimes nodose at the intersection.

FIG. 15. *Clavilithes rugosus,* the protoconch of fig. 7, pl. IX.

Gerontic characteristics are shown by the separation of the inner lip from the columella, and the consequent formation of an umbilicus (pl. IX, fig. 3). Also by the disappearance of the ribs and the excessive development of the posterior canal.

An elongated variety of this species is figured in fig. 8, plate IX. In this the whorls are loosely coiled, appearing more rounded; the ribs are more pronounced throughout, and secondary spirals are well developed. This latter feature marks this variety as more accelerated in development in this respect, than the normal species.

Localities: Paris Basin (M. C. Z. 1380, 1373, 1377 var., 1378); Grignon (M. C. Z. 1374, 1379, 1375). Var. M. C. Z. 1413, Young M. C. Z. 1125.

Horizon: Calcaire Grossier; Eocene.

CLAVILITHES DAMERIACENSIS (Deshayes).

(Plate X, figs. 5 to 8; Plate XI, fig. 6.)

1866. *Fusus dameriacensis* DESHAYES, Anim. sans vert., T. 3, p. 256, pl. 85, figs. 23, 24.

The protoconch of this species is of the normal papillose type, of a little more than three volutions, umbilicated and with septa. The last portion is furnished with fine vertical riblets which are smooth, but have fine thread-like spirals in the interspaces. This merges into the normal whorls of the conch.

The conch is ribbed and spirally striate from the beginning, the whorls changing from the cylindrical form of the protoconch to a rounded one. They embrace up to the middle of the preceding whorl, thus making the ribbed spire less elongate. This is the chief difference between the young of this species and *C. rugosus.* The ribs, at first strong and widely distant and uniform throughout, increase in strength on the periphery but become obsolete towards the sutures. In the fourth or fifth volution the ribs disappear altogether, while at the same time intercalated spirals appear between the primary ones. The spirals are uniform and equidistant except near the suture, where they are more crowded. The last whorl or two of the conch are ribless, rounded and covered with more or less strongly marked spirals, which become

weaker, however toward the end. The subsutural band and posterior canal are well developed and characterize all the whorls from the neanic on. It is generally emphasized by a concavity which marks the upper portion of all the later whorls, and is also faintly traceable on the earliest ones.

The characteristic features of this species are the strongly ribbed young spire, in which there are from three to five volutions, and the spirally striate ribless volutions of the adult. Both these features show that this shell is still quite primitive when compared with the other species of this series, in which the spire is scarcely ribbed, and the last whorls are smooth and free from spirals.

The rounded whorls without ribs, but with spirals, mark the *dameriacensis* stage of the species of this series. When present this stage always follows the ribbed *rugosus* stage. The present species, *C. dameriacensis,* consists of these two stages, the development of both being about equal.

Locality: Paris Basin (M. C. Z. 27750, 27724, 27775, 27778).

Horizon: Middle Eocene, Calcaire Grossier (Desh.).

CLAVILITHES CONJUNCTUS (Deshayes).

(Plate X, fig. 6; Plate XI, figs. 1–5.)

1837. *Fusus conjunctus* Deshayes, Coq. Foss. Env. Paris, t. 2, p. 527, pl. 70, figs. 16, 17.

1889. *Clavilithes conjunctus* Cossmann, Cat. Coq. Foss., p. 174.

The protoconch of this species consists of from three to four volutions, and has all the characteristics normal to this series. It merges into the conch.

The conch is spirally striate, the spirals being uniform and equidistant. Towards the end of the first volution undulations appear, and these in some specimens in the collection rise to the distinctness of ribs. They are never very prominent, however, and after two or three volutions they disappear again. Thus the *rugosus* stage is condensed in this species. This is followed by a short *dameriacensis* stage, in which the ribless but round whorls are marked by strong spirals. These spirals are strongest on the upper portion of the whorl, but become faint and finally obsolete on the lower portion. Intercalated spirals appear usually in the second or third volution of the conch, though in some specimens they do not occur until considerably later.

The whorls of the *dameriacensis* stage are succeeded by those of the *conjunctus* type. These, the final and typical whorls of this species, are still rounded but perfectly smooth or with the spirals so weak as to be scarcely visible. This represents the next stage in advance of the *dameriacensis* stage, and when well developed requires a condensation of the earlier stages to make room. On typical specimens between

two and three whorls of this type exist, and from one to two whorls of each of the preceding. In some specimens the ribbed *rugosus* stage is scarcely developed.

All the changes are gradual and the stages merge into each other. The variations of this species lie between *C. dameriacensis* and *C. parisiensis,* and the varieties approach the one or the other, according to the smaller or greater amount of acceleration which they have experienced. The greatest variation is in the length of the ribbed portion of the spire, some specimens of this species approaching the more accelerated specimens of *C. dameriacensis* and establishing a complete gradation between the two species.

The concavity seen on the whorls of *C. dameriacensis* is also slightly traceable on the adult whorls of some specimens of *C. conjunctus* (Plate XI, fig. 1). It usually contains faint spirals while the remainder of the whorl is smooth. The concavity is also indicated on Deshayes' figure.

The neanic stage of this species (Plate XI, fig. 3) is the structural equivalent of the ephebic stage of *C. dameriacensis,* the shell in both cases being characterized by the absence of ribs, and by well-developed spirals. The *conjunctus* characters may be assumed long before the shell has reached full size. In that case the young *C. conjunctus* is indistinguishable from the young *C. parisiensis* which passes through a *conjunctus* stage before it attains the *parisiensis* character of the adult. We may, however, assume with good reason that young shells, in which the *rugosus* stage persists long and is succeeded by a *dameriacensis* stage, will probably not pass beyond the *conjunctus* stage, *i. e.,* that these are immature *C. conjunctus.* On the other hand those shells in which the early stages are abbreviated or eliminated, will probably pass beyond the *conjunctus,* and into the *parisiensis* stage; these, therefore, are the young (neanic) of *C. parisiensis.* No sutural shelf or terrace appears on this species, though it may appear in an extremely gerontic individual. Nevertheless, in some adult specimens there is a slight thickening below the suture, producing a subterraciform appearance. This is precisely the character of the whorls of an immature *C. parisiensis.* The adult *C. conjunctus,* therefore, is the structural equivalent of the neanic *C. parisiensis.*

Each stage is characterized only by the features which belong to the adult whorls of the species after which the stage is named. Thus the *dameriacensis* stage is that portion of the shell in which the whorls are round without ribs and marked by spirals. The species (*dameriacensis*) must, however, have these characters in the adult whorls and it must have a *rugosus* stage preceding it. This *rugosus* stage may be long or short—in the typical specimens it is long. We may find, however, specimens in which acceleration is confined to the early

stages; *i. e.*, the *rugosus* stage may be condensed and the *dameriacensis* stage remain for a longer time, probably through adult stages. This would still be a *C. dameriacensis*, but a variety in which the early stages are accelerated. Thus specific characters are based on adult characteristics to a large extent; *i. e.*, on the stage which the adult has reached in development. If a specimen should be found in which the *rugosus* stage has been dropped altogether and the *dameriacensis* stage follows on the protoconch, and never reaches the *conjunctus* stage even in the ephebic condition, it might be desirable to call it another species, even though the adult has the true characters of *F. dameriacensis*. It is not likely, however, that acceleration would act so locally for we may expect that the spirals become obsolete and a true *conjunctus* stage appear. In a highly accelerated *C. conjunctus* the *rugosus* stage may be eliminated, but not the *dameriacensis* stage. On the other hand, acceleration may act not in the nepionic but in the neanic stage (Plate XI, fig. 2). The *rugosus* stage may be well developed, and may have strength to resist condensation so to speak, but the *dameriacensis* stage may be less resistant, and hence be eliminated by acceleration. Thus the *conjunctus* stage may follow immediately upon the *rugosus*, without or with but a short *dameriacensis* stage between.

Again, acceleration may act equally on all stages, condensing the earlier ones, but not eliminating any of them. Then the typical form of the species is produced.

Localities: Paris Basin (Cuise) (M. C. Z. 1068); Parnes (M. C. Z. 1065, 1066, 27743); Chaumont (Acad. Sci. 6882); Paris Basin (M. C. Z. 1067, 27764).

Horizon: Middle Eocene, Calcaire Grossier. (Also recorded by Deshayes from the Sables moyens, Upper Eocene.)

CLAVILITHES CONJUNCTUS, senile variety.

(Plate XIII, fig. 10.)

This specimen differs from the normal form of the species in its acceleration of senile characters, which in the present individual appear in the late neanic and early ephebic stages. The chief characteristic is the looseness of the coil at these stages, which results in the production of an external sutural canaliculation. A slight looseness of coiling is observable in some typical young of *C. conjunctus*, and in the present individual a similar slight looseness goes back to the late *dameriacensis* stage. The separation increases steadily, until the specimen at the age and size of the early ephebic of a normal *C. conjunctus* shows a very decided loosening of the last whorl. Coincident with this feature the last whorl has become more cylindrical, departing from the rounded character normal to *C. conjunctus*. The aperture has also

become more elongate and narrower, the outer lip being nearly straight instead of uniformly curved as in typical individuals of *C. conjunctus.*

In the character of the whorl and the outline of the outer lip, as well as the profundity of the posterior canal, this shell approaches the young of *C. parisiensis,* but that species has a sutural shoulder or terrace, and not a canal, as in the present individual. The features are sufficient for specific distinction, but since only one specimen is known it is better to consider it a gerontic or highly accelerated individual.

Horizon and Locality: Paris Basin, Calc. gross. (Grobkalk.) Coll. Bronn. (M. C. Z. 1105).

CLAVILITHES PARISIENSIS (Mayer-Eymar).

(Plate X, fig. 10; Plate XI, figs. 7–9.)

1803. *Fusus longævus* LAMARCK, Ann. du Mus., t. I, p. 317.
1816. *Fusus longævus* var. LAMARCK, Encycl. Meth., pl. 425, fig. 4; also *F. clavellarus* var., ibid., fig. 2 *a–b.*
1837. *Fusus longævus* DESHAYES, Coq. Foss. Env. Paris, t. 2, p. 525, pl. 74, figs. 18, 19.
1840. *Clavilithes longævus* SWAINSON, Treatise on Malacology, p. 304, fig. 72 *b.*
1866. *Fusus longævus* DESHAYES, Anim. sans vert., t. III, p. 256.
1877. *Fusus* (*Cyrtulus*) *parisiensis* MAYER-EYMAR, Pal. Pariserstufe von Einsiedeln, p. 89.
1889. *Clavilithes deformis* COSSMANN, Cat. Coq. Foss. Eoc. Env. Paris, p. 173.
Not *Murex longævus* SOLANDER, Brander's Foss. Hants., 1766, p. 22, pl. II, fig. 40, pl. VI, fig. 73.
Not *Murex deformis* SOLANDER, ibid., p. 22, pl. II, figs. 37–38, pl. VIII, fig. 83.

It is very unfortunate that the well-known type species of the genus *Clavilithes,* the *Fusus longævus* of Lamarck, should have to suffer transference from one specific name to another. Since the specific name was preoccupied by Solander in 1766 for a totally distinct species of the British Eocene it can not be retained for the Paris Basin species, the type of the genus. M. Cossmann, the eminent French authority on the fossils of the Paris Basin, has recognized this point, and sought to rectify it by applying Solander's name *F. deformis* to the type species, holding that the French species is identical with the British one to which Solander applied that name. I feel convinced that that is a mistake. The types of Solander's *Murex deformis* were very young specimens, the one in the early nepionic, the other in the early neanic stage. The protoconch in both cases is heavy and irregular, of the type shown in the specimen pl. XIV, fig. 5. The early whorls are also depressed or flattened in the upper exposed portion, thus producing a trochoid rather than a naticoid apex.

It seems to me highly probable that the specimens figured by Solander are the young of the large species so characteristic of the British Eocene, which is herein described under the name *Clavilithes solanderi,* new species, and which Solander figured as a variety of his

Murex longævus (Sol. fig. 93). (See pl. XIV, figs. 5 and 6, and pl. XV, figs. 1 and 2.) It is not improbable, however, that the young specimen of Solander's figure 37 may prove to be the young of *C. longævus* (Solander) not Lamarck (pl. XIV, fig. 8).

This leaves Mayer-Eymar's name *F. parisiensis,* proposed in 1877, as the only available one for the type of the genus *Clavilithes.* This is certainly a most appropriate name, since the species in its typical form is unknown outside of the Paris Basin.

In view of the uncertainty which is attached to the types of Solander's *Murex deformis,* and in view of the fact that this species was based on material too young to allow determination of its true specific relationships, I propose to discard Solander's name *deformis* entirely, and to apply the name *C. solanderi* nom. nov., to the large characteristic species of *Clavilithes* of the British Eocene.

Description of Clavilithes parisiensis.

The protoconch is of the normal papillose type, with minute apex, and naticoid early whorls. No varix has been observed. On the latter part of the smooth portion a few faint vertical plications exist. Faint spirals are visible between.

In all the broken specimens the septum appears as a funnel-shaped, curved closing element of the protoconch. The septum makes about a third volution, so that the tip is perhaps half a volution further within the protoconch. The distal end (tip) of the septum is uniformly rounded and lies free in the cavity of the protoconch with the exception of that portion which lies next to the columella, which is generally united with the latter. The protoconch is still umbilicated at this stage. There is some variation in the form and outline of the septum in different individuals. Septa have also been noticed in later portions of the shell, after the normal characters of the conch have appeared. Similar septa have also been observed in other species of this genus.

The conch begins with whorls which are ribless but marked by strong revolving lines or spirals. These are uniform, subequal, at first closely crowded, later more and more widely separated.

The succeeding portion varies somewhat. In one variety, which is strongly accelerated, the ribs are almost obsolete, the whorls being smooth, except for the spirals (pl. XI, fig. 7). In another less accelerated variety, the ribs are quite strongly developed, of the *rugosus* type, distant and bulging near the center. Intercalated spirals appear in the third whorl of the conch or later. When the ribs are well developed the whorls have the aspect of the young *C. dameriacensis,* from the close coiling of the volutions and the strong development of spirals (pl. XI, fig. 9).

The *rugosus* stage is succeeded by a *dameriacensis* stage, which is usually short and consists of rounded whorls, free from ribs, but ornamented by strong spirals. With the disappearance of the spirals the *dameriacensis* merges into the *conjunctus* stage, which is, as a rule, strongly developed in this species, even though the *dameriacensis* stage should be absent. This is particularly the case in the varieties with a short or obsolete *rugosus* stage, the suppression of which leaves room for the development of the *dameriacensis* and *conjunctus* stages (pl. XI, fig. 7). When, however, the *rugosus* stage persists, the *dameriacensis* and *conjunctus* stages are abbreviated, the *parisiensis* stage following soon after the *rugosus* (pl. XI, fig. 9; pl. X, fig. 10). In this respect fig. 8 of pl. XI is intermediate between fig. 7 and 9 of the same plate. In some accelerated individuals the *rugosus* stage is almost eliminated, but the ribless, spiralled *dameriacensis* stage is well marked. This is followed by the *parisiensis* stage, the *conjunctus* stage being eliminated. In the early stages of the more characteristic specimens of this species the subsutural concavity on the upper part of the whorls, which is characteristic of *C. conjunctus*, is well developed.

In the adult or ephebic stage, a sutural shelf is developed and the aperture contracts until the side of the whorl is parallel to the longitudinal axis of the shell. The body-whorl thus becomes cylindrical. This is the *parisiensis* stage, and when it occurs in conjunction with the *conjunctus* and *rugosus* stages we have a typical *C. parisiensis*. The *dameriacensis* stage may or may not be present, according to the degree of acceleration which the shell has experienced. Variation is also produced by the unequal acceleration of different stages of the shell, one or the other of which may be developed at the expense of the adjoining one. Thus a number of varieties are produced which shade into each other and connect this species with others of this series.

In an injured or gerontic specimen (M. C. Z. 1081, pl. X, fig. 10) the last portion of the last whorl assumes again the features of the *conjunctus* stage. The shoulder disappears and the lines of growth become lamellose and crowded while the whole whorl becomes more globose. Similar features are seen in injured specimens of all sizes. The shoulder expression of the whorl below the suture is not at once regained, but a rounded indefinite form, lying between *C. parisiensis* and *C. conjunctus* is produced. One specimen only has been observed (M. C. Z. 1093) in which the last part of the last whorl, of a moderate sized specimen had a projecting shelf similar to that of *C. scalaris*. The specimen is from Anvers.

Localities: Chaumont (M. C. Z. *1073*, Agassiz); Parnes (M. C. Z. 1075, Baucault, *27753*, Duval); Grignon (M. C. Z. 1079, *1081*, Duval; Acad. Sci. 8025, 6892); Mt. St. George (Cossmann); Chaumery (M. C. Z. 1076, Koninck, *27787*); Cuise (M. C. Z. 1095); Paris (M. C. Z.

1069, *1072*, 27752, 1078, 1118; 27725, 27755, 27756; Auvers (M. C. Z. 1093); Loins (M. C. Z. 27758).

Horizon: Eocene (Middle; Deshayes). Calcaire grossier.

CLAVILITHES TUBERCULOSUS (Deshayes).

(Plate X, fig. 4.)

1837. *Fusus tuberculosus* DESHAYES, Coq. Foss. Env. Paris, t. 2, p. 522, pl. 73. figs. 14, 15.

1889. *Clavilithes tuberculosus* COSSMANN, Cat. Coq. Foss., p. 174.

The shell here illustrated, though immature, appears to be a distinct species derived from *C. dameriacensis*. I have identified it with Deshayes' *Fusus tuberculosus*, which, as far as description and illustration allow us to judge, has the characters found in the shell under consideration. The early stages are like those of *C. dameriacensis*, the *rugosus* stage being represented by a number of ribbed whorls and the *dameriacensis* stage by spirally striate rounded whorls. Toward the end of the latter, however, the sutural shelf characteristic of *C. parisiensis* is developed, without the change from a rounded to a cylindrical form of whorl. This association of *dameriacensis* and *conjunctus* type of whorl with *parisiensis* shelf appears to be characteristic of this species and indicates an unequal acceleration, where a feature characteristic of a late stage in one series is added to those characteristic of an earlier stage in the same series. In other words, one feature is accelerated while the others are correspondingly retarded in development. The subsutural concavity characteristic of *C. conjunctus* is strongly developed in this species, and to this is due the rotund character of the whorl, which is ordinarily lost with the development of the sutural shelf. This shelf is an independent development in this species.

The ribs of the *rugosus* stage of this species are usually much stronger than those of the corresponding stage of *C. dameriacensis*, and give the characteristic tuberculous appearance at the suture. Since the specimens which I have seen are all immature it is impossible to be certain that they do not represent the young of the next species (*C. subscalaris*). As will be shown later, *C. subscalaris* passes through a stage (neanic) which is the structural equivalent of the adult (ephebic) stage of *C. tuberculosus*.

A specimen from the middle Eocene of Parnes (Acad. Sci.) which has been identified by Cossmann with this species has more the characters of an excessively thick-set and short-spired *C. rugosus*. The whorls are bulging, and the ribs are far apart and swollen in the middle. They become obsolete toward the sutures, below which there is a strong concavity. On the last whorl the ribs are fainter, and the concavity

is strong. There is no sutural shelf, and the spirals are strong. This is probably an immature shell in which the shelf has not yet appeared. The shelf is shown in Deshayes' figure of this species.

Localities: Paris (M. C. Z. 1116, Koninck); Parnes (Acad. Sci. 6901, Cossmann, M. C. Z. 27760); Grignon (B. S. 1412).

Horizon: Middle Eocene, Calcaire Grossier.

CLAVILITHES SUBSCALARIS sp. nov.

(Type Plate XII, fig. 9; var. Plate X, fig. 1; Plate XII, figs. 1–3, 7, 8, 10–12.)

This species is generally classed with *C. parisiensis* to which it bears a close resemblance in many respects, and especially to accelerated individuals of that species. It is, however, a much more accelerated species and typical individuals are readily distinguished. The early stages are generally much condensed, and the characteristic sutural shelf appears in the early whorls, usually before the characteristics of the early stages have disappeared.

In the pre-ephebic stages this species has all the characters of *C. tuberculosus,* but it passes beyond that stage, assuming the cylindrical shelved whorls characteristic of *C. parisiensis* with which it is identical only in the ephebic stage.

The diagnostic characters may be summed up as follows: Protoconch and earliest volutions normal. The ribbed stage occupies usually a few whorls only. Succeeding ribless whorls are generally convex, but soon merge into the cylindrical ones. The sutural shelf appears with the disappearing of the ribs, sometimes earlier. It is strongly developed, often projects outward to some extent, but does not form the distinct rim of *Clavilithes scalaris.* Adult stage as in *C. parisiensis.*

The most prominent character of this species is the early appearance of the sutural shelf which is also characteristic of *C. scalaris.* But that species forms a projecting sutural rim or flange in the adult which does not occur in *C. subscalaris.* There are many intermediate forms which connect this species with *C. parisiensis,* and hence some authorities consider them conspecific. It may, however, be emphasized that similar gradations exist between practically all the species of the genus.

The variations of this species are readily determinable from a consideration of the various ways in which the stages can be combined. By acceleration of one and retardation of another character, distinct and important varieties are produced which form the connecting links between the primitive species on the one hand, and the highly progressive on the other, thus showing an uninterrupted development governed according to the law of acceleration.

An individual showing all the stages is illustrated in fig. 7 of pl. XII. In this specimen about two whorls are in the *tuberculosus* stage, followed by one and a half whorls with *parisiensis* characteristics. A

strongly accelerated variety is shown in fig. 3, pl. XII, and a slightly less accelerated one in fig. 2 of the same plate. In the first of these specimens the protoconch which consists of three and a half volutions is followed by a smooth and spirally striate rounded whorl. This and the succeeding whorls embrace each other closely, thus producing a short and swollen spire. Faint undulations occur on some of the whorls but there are no ribs. There are two spirally striate whorls without shelf (*dameriacensis* stage). The shelf appears in the third whorl. Toward the end of the fourth whorl the spirals have become obsolete and the whorl changes from rounded to cylindrical. A very pronounced posterior canal is developed. In fig 2 the whorls embrace in a similar manner but about two whorls of the *rugosus* stage (ribbed) are retained. With the disappearance of the ribs the sutural shelf makes its appearance, and later the spirals disappear. A *subtuberculosus* and a *tuberculosus* stage is produced. This is followed by a short *parisiensis* stage. Fig. 1 of plate XII represents another accelerated variety. Here the shelf appears while the ribs are still represented by undulations (this may be called a *rugoso-tuberculosus* stage). This is succeeded by a very short *tuberculosus* stage (the spirals having disappeared with the ribs), and this quickly merges into the *parisiensis* stage. The *rugosus* stage is very persistent, there being at least four complete volutions. Fig. 4 of plate XII represents an immature *C. parisiensis* which has scarcely passed beyond the *conjunctus* stage. The last part of the whorl shows a deformation.

A strongly marked variety from Paris is shown in fig. 8 of plate XII. This might well be considered a distinct species. The spire is short and the last whorl is thick, condensed and with a long anterior canal. The protoconch is furnished with a few narrow vertical riblets. These are followed by the normal ribs of the conch which are characteristic of about three volutions. A sutural shelf is formed, before the ribs fully disappear, giving a short *rugoso-tuberculosus* stage. A short *subtuberculosus* stage (like *tuberculosus* but with spirals) follows, and is in turn succeeded by a smooth *tuberculosus* stage. These three shelved and round-whorled stages are very short, and soon give way to the cylindrical whorls of the *parisiensis* stage. Thus the present variety of *C. subscalaris* consists of a *rugosus*, a short *rugoso-tuberculosus*, a short *subtuberculosus*, a longer *tuberculosus* and a well-developed *parisiensis* stage.

Figs. 5 and 6 of plate XII show young specimens of accelerated varieties of perhaps this species, but more probably of *C. scalaris*. In fig. 5 the ribbed stage is absent altogether, having been dropped out (acceleration by elimination). The whorls are all round and spirally striate, intercalated striæ arising in the third whorl. The sutural shelf appears while the spirals still continue (*subtuberculosus* stage).

In fig. 6 the ribs are very faint, but otherwise the specimen is like the preceding except that in the last portion of the last whorl the shelf projects slightly outward as in *C. scalaris*. This occurs before the disappearance of the spirals which are simple, or with intercalations only in the upper part of the whorl. In fig. 10 is shown a young specimen in the *tuberculosus* stage, the shelf appearing at about the time of the disappearance of the spirals. In fig. 11 is shown a specimen in which the shelf is faintly marked in the ribbed stage, though perhaps scarcely sufficiently to be considered a *rugoso-tuberculosus* stage. The *subtuberculosus* stage is very short, having been practically eliminated. The *tuberculosus* stage occupies about half a volution, and is followed by the *parisiensis* stage. In figs. 1, 10 and 11 the ribbed whorls (*rugosus* stage) are unusually persistent.

Fig. 9, the type of the species, is a strongly accelerated individual of the *Clavilithes* series. The shelf appears in the fourth whorl before the ribs have disappeared (*rugoso-tuberculosus* stage) and rapidly becomes prominent. The spirals disappear with the ribs, thus cutting out the *subtuberculosus* stage. The *tuberculosus* stage continues for about half a volution or more, and then merges into the *parisiensis* stage. The shelf becomes very prominent and begins to project beyond the shell below, thus faintly approaching the characters of the *scalaris* stage. This stage, however, does not occur.

Fig. 12 shows a differently accelerated individual. The *rugosus* stage is short and faintly ribbed, the shelf not being formed until the disappearance of the ribs. A short *subtuberculosus* and longer *tuberculosus* stage occurs, and then the *parisiensis* stage becomes strongly developed. This, therefore, is a typical *C. subscalaris* only with the earlier stages differently accelerated than in fig. 9.

A specimen from Loins, France (M. C. Z. 27754), is extremely accelerated. There are two and a half normal *rugosus* whorls, then a subsutural thickening occurs, which soon develops into a shelf. This though narrow is pronounced. There are nearly two volutions which have ribs and a shelf, the latter even projecting slightly after the *scalaris* manner. The spirals disappear half a volution or more before the ribs, the latter gradually passing into undulations. Shortly after the disappearance of the ribs the whorls become cylindrical and the shelf is no longer rimmed.

Localities: Paris (M. C. Z. 1077, Bronn; 1071, Lyell; 1102, Duval, 1070; 27748, Duval; 27757, Dyer); Cuise-Lamotte (M. C. Z. 27749); Chamery (27744; 27745 Type; 27769 young?); Nanteuil (M. C. Z. 1074, Reneault); near Nantes (M. C. Z. 27751); Parnes (M. C. Z. 27742); Chaumont (M. C. Z. 27747); Loins (M. C. Z. 27754, Dyer).

Horizon: Middle Eocene, Calcaire Grossier.

CLAVILITHES SCALARIS (Lamarck).

(Plate X, figs. 2, 3; Plates XIII, figs. 13, 15–20.)

1816. *Fusus scalaris* LAMARCK, Encyclop. Meth. Tab., 425, fig. 7.
1822. *Fusus scalaris* LAMARCK, Anim. sans vert., t. VII, p. 134.
1837. *Fusus scalaris* DESHAYES, Coq. Foss. Env. Paris, t. 2, p. 525, pl. 72, figs. 13, 14.
1866. *Fusus scalaris* DESHAYES, Anim. sans vert., t. III, p. 257.
1889. *Clavilithes longævus* COSSMANN, Cat. Coq. Foss., p. 172.
Not *Murex longævus* SOLANDER, Brander's Foss. Hants., p. 22, pl. II, fig. 40, and pl. VI, fig. 73. 1766.

This species is the terminal member of the series as far as developed within the Parisian province. It is a highly accelerated type, the ribbed *rugosus* stage being very short or dropped out altogether. The sutural shelf begins early while the spirals are still strong on the *subtuberculosus* whorl. Not infrequently the shelf appears in the ribbed whorls, forming a *rugoso-tuberculosus* stage. In some specimens the shelf appears as early as the third volution. A *tuberculosus* and a *parisiensis* stage normally follow the *subtuberculosus* stage, but one or both may be absent in highly accelerated varieties. The final stage of this species—the *scalaris* stage—is brought about by the deepening of the depression below the suture. The shelf as a consequence projects beyond the whorl as a rim. Coincidently the shoulder has become very wide and is bordered by the swollen edge of the rim. The posterior canal corresponding to this form of shelf has a T-shaped outline.

There are several distinct varieties of this species. In the most typical one (see Deshayes' figure) the shoulder appears after two or three whorls of the conch and the ribs are almost obsolete. The projecting rim may appear while the shell is still in the *tuberculosus* stage; *i. e.*, round smooth-shelved whorls without spirals. Or it may appear simultaneously with the appearance of the *parisiensis* stage; *i. e.*, when the smooth-shelved whorl becomes cylindrical. The *subtuberculosus* stage may be crowded out and the *tuberculosus* stage follow directly upon the *rugosus*. Again, both *subtuberculosus* and *tuberculosus* stages may be eliminated, and the *parisiensis* stage follow upon the *rugosus* stage.

Numerous other variations are possible, and their characteristics may be determined by permuting and combining the characters of the various stages and substages in every manner possible. In a large collection all or nearly all these possible variations may be found, since hardly any two individuals are exactly alike. Except in the most accelerated individuals a neanic *C. scalaris* and an ephebic *C. subscalaris* are structurally equivalent, and every *C. scalaris* has the characters of an adult *C. subscalaris* before it acquires those typical of its own species.

Specimen fig. 2 of plate X has two ribbed volutions followed by a *subtuberculosus* stage, with spirals and shoulder, of something less than a volution. With the assumption of the cylindrical form the shelf begins to project, so that the *parisiensis* stage is practically dropped out altogether.

In fig. 3 of the same plate is a differently accelerated individual. A *rugoso-tuberculosus* stage occurs, the last ribbed whorl having a narrow shelf. A short *subtuberculosus* stage follows, but the whorl quickly becomes cylindrical, and the shelf begins to project. The spirals are still retained and they occur in the last whorl where the shelf projects strongly. The whorl is still convex, owing to the strong constriction below the shelf. The shelf is turned slightly upward.

Fig. 13, pl. XIII, shows a young specimen with *rugosus, subtuberculosus* and *tuberculosus* stages. The shelf begins to project in the latter. Figs. 15 and 17 show young individuals in the *subtuberculosus* stage. Fig. 16 shows a specimen which in the early neanic stage resembles *C. subscalaris,* while figs. 18 and 19 show young specimens which likewise have just passed the stage in which they had the characters of *C. subscalaris.* In the majority of specimens the *subtuberculosus* or *tuberculosus* stages occur, followed frequently by a short *parisiensis* stage, before the shelf begins to project. In many specimens the shelf slopes outward instead of inward.

In the collection of the Philadelphia Academy of Sciences is a small specimen of this species in which the permanent projecting shelf begins almost in the first ribless volution. There are about two ribbed and spirally striate volutions (*rugosus* stage) followed by a short ribless and spirally striate volution in which there is a strong shelf (*subtuberculosus* stage). The characteristic projection of the shelf appears immediately after this, before the disappearance of the spirals. Thus the *tuberculosus* stage as well as the *parisiensis* stage is crowded out.

Localities: Chaumery (M. C. Z. 27760); La Chapelle (M. C. Z. 1083); Paris (M. C. Z. 1084, Bronn; 1085, 1086 Agassiz); Jancron (M. C. Z. 1087); Bazile (M. C. Z. 1888); Auvers (M. C. Z. 1089, 1090, 1091, 1092, Duval); Montmiraille (M. C. Z. 27786); Le Guepelle (Acad. Sci. 6893, Cossmann).

Horizon: Upper Eocene: Sables Moyens, lower and middle beds, but not the upper (Desh.). At Coumant specimens were found ranging from 18 to 20 and 22 centim. in length, and 65 mm. in width (Desh. 1866).

CLAVILITHES MACROSPIRA Cossmann.

1889. *Clavilithes macrospira* Cossmann, Ann. Soc. Roy. Mal. de Belgique, t. 24, p. 173, pl. 6, fig. 7.

This is an accelerated species in which the shelf appears early, but the whorls never become cylindrical; they rather assume a conical shape.

In this respect, as well as appearance generally, it recalls the typical British species *C. solanderi,* but since *C. macrospira* was described from imperfect material its identity with the British species is not proved. Should more perfect material show this identity, Cossmann's specific name will of course supersede mine.

Cossmann states that the young whorls are ornamented by ribs and spirals, but that these have disappeared on the fifth whorl before the last, the final ones being smooth.

Two specimens from the Paris Basin (M. C. Z. 27761), though worn, show the characters of this species. The earliest whorls are broken away and the characters of the youngest stages is, therefore, not determinable. The final portions of the last whorl have a *scalaris*-like projection of the shelf.

This species may have been derived from *C. subscalaris* by flattening of the upper portion of the whorls.

Localities: Paris Basin (M. C. Z. 27761).

Horizon: Upper Eocene (Cossmann).

CLAVILITHES MAXIMUS (Deshayes).

1824. *Fusus maximus* DESHAYES, Coq. Env. Paris, p. 526, pl. 71, figs. 11–12.

1850. *Fusus maximus* DESHAYES, Rouault, Foss. Eoc. Env. Pau, T. III, pt. 2, p. 489, pl. 17, fig. 8.

1889. *Clavilithes maximus* (DESHAYES) COSSMANN, Cat. Coq. Eoc. Paris, T. 4, p. 177.

This very large and robust species from the middle Eocene of Chaumont, etc., is of somewhat uncertain affinities.

According to Rouault, Deshayes' figure does not agree with the description given by that author, the illustrated specimen being doubtless a very old and worn individual. The shell figured by Rouault is stated to have in the neighborhood of fourteen whorls, the last of which have a strong shelf. Only six whorls are shown, the top being broken away, and there probably were not above three or four more. The ribs are broad, separated by less than their width, and they persist into the penultimate whorl as faint wrinkles or undulations. Intercalated spirals are shown on the earliest preserved whorls. The shelf begins on the last of the ribbed whorls, is well developed and horizontal. On the preceding whorls it is replaced by a subsutural band. The whorls become cylindrical after the appearance of the shelf, and the spirals persist, though faintly, onto the otherwise smooth body-whorl. They are strong on the spindle. The total length of the shell figured by Rouault must have been between five and six inches. The shell resembles the British *C. solanderi,* but the ribbed whorls continue longer, the sides are parallel to the axis instead of converging; the shelf is horizontal instead of sloping inward, and the spirals are persistent, especially on the spindle.

Localities: Chaumont, Bos d'Arros.
Horizon: Middle Eocene, Calcaire grossier.

CLAVILITHES DEFORMIS (Solander).

In the British Eocene.

(Plate XIII, fig. 14; Plate XIV, figs. 1, 3 and 4; Plate XVIII, figs. 7 and 8.)
1766. *Murex deformis* SOLANDER, Brander's Foss. Hants., p. 22, pl. II, figs. 37, 38.

The species was described by Solander from immature specimens obtained from the Eocene of the Hampshire basin. As has already been remarked the name is best discarded, since the precise relations of the species of which these specimens are the young must always remain doubtful. They probably belong to *C. solanderi* Grabau, and according to strict ruling Solander's name should have priority. There is, however, the above-mentioned element of doubt, which makes such ruling in this case a questionable expedient.

In plate XIII, fig. 14, is illustrated a characteristic example of the young *Clavilithes* comparable to *C. deformis* (Solander) as it occurs in the Eocene clays of Barton.

The protoconch (pl. XVIII, figs. 7 and 8) is much larger and more robust than is even the case in the French species of the genus. Its median whorl has a diameter of nearly 4.5 mm., while the average diameter of the median whorls in the French species is less than 3 mm., seldom exceeding 2.5 mm. In one specimen from Barton the diameter of the median whorl of the protoconch was found to be 5 mm. There are, however, specimens in which the protoconch approaches in size more nearly that of the French species. The number of volutions varies from three to nearly four, and they almost always show an irregularity in thickness. A characteristic feature not found in the French species is the flattening of the upper exposed portion of the early whorls of the protoconch, thus giving a sloping or trochiform character to the apex (pl. XVIII, figs. 7 and 8). The apex of the protoconch of the Parisian species is naticoid with the convexity of the whorl unimpaired.

In the conch the spirals appear before the ribs. The latter are at first mere undulations which, however, quickly become pronounced in most cases. In some accelerated types the ribs never appear, the early whorls being merely spirally striate. The contour of the early whorls is strongly convex. Intercalation of spirals does not appear until after the second volution of the conch.

There is great similarity in general appearance between the British young shells described as *C. deformis* and the young of *C. subscalaris* and *C. scalaris* from the Paris Basin beds.

Localities: Common in the Barton Beds of the Hampshire Basin (M. C. Z. 27783) Bracklesham (M. C. Z. 27765).
Horizon: Upper Eocene.

CLAVILITHES PARISIENSIS (Mayer-Eymar).

In the British Eocene.

(Plate XIV, figs. 7 and 9.)

So far as I am able to judge from the limited amount of material in my hands, this species, while represented in the British Eocene, did not attain its normal development as found in the specimens from the Paris Basin. It is perfectly possible, as far as my observations go, to distinguish the Hampshire basin specimens from those of the Paris Basin, even though we overlook the difference in color. This is probably to be correlated with difference in facies between the two regions, which must have caused an effective separation of the two faunal provinces even though no other barrier existed.

In fig. 4, pl. XIV, is shown an immature specimen which may belong to this species. The protoconch is not widely different from that of the Parisian specimens, though the apex is less depressed than in those from the Calcaire Grossier. There are something over four volutions, after which the spiralled and ribbed conch begins. The *rugosus* stage is short, followed by a pronounced *dameriacensis* stage. Before the disappearance of the spirals a thickening of the suture occurs which marks the beginning of the sutural shelf. The contour of the whorl changes but slightly, still it becomes progressively less convex. In this and in specimen fig. 3 of the same plate in which the *rugosus* stage is more pronounced, is a suggestion of the *tuberculosus* characteristics, from the appearance of a shelf, while the whorl is still of a convex contour. This is particularly the case in fig. 3, where the strong *rugosus* characters give the nodulose appearance so characteristic of *C. tuberculosus* (Desh.). The same features are shown in specimen fig. 1 of the same plate. Here the *rugosus* characters persist still longer, but the spirals on the ribless whorls are less pronounced. An imperfect shelf with a subsutural concavity and rounded contour of whorls strongly suggests the accelerated type *C. tuberculosus* of the Paris Basin. It would be hazardous, however, to consider the present immature shells of this species, particularly since the shelf is scarcely more than a thickening of the edge of the whorl, such as may occur in abnormal specimens of *C. conjunctus* or *C. dameriacensis*. A distinct shelf does appear in the young of some specimens of *C. solanderi* and *C. longævus*, while the contour is still convex.

A specimen from the Barton beds, Hampshire, has the protoconch and early whorls of the conch broken away (pl. XIV, fig. 7). About two ribbed volutions occur followed by one which has the characters of *C. dameriacensis*, being rounded and spirally striate. This is followed by a whorl in the *conjunctus* stage and one in which a cylindrical form and a sutural shelf occur, the latter, however, not being flat, but

sloping outward. Gerontic characteristics are shown by a thickening of the lip through a piling up of layers, and by the formation of a deep posterior canal, as well as a slight sutural canal.

Another adult specimen from the Bracklesham beds of New Forest, Hampshire (pl. XIV, fig. 9), shows a septum near the end of the protoconch, and an acceleration in the nepionic stage, in which the non-undulate spirally striate character, usually seen only in the last stages preceding the *conjunctus* stage, makes its appearance. A few faint undulations are, however, still visible in the early nepionic stage. There are about three volutions, which have the form and spirals of the *damcriacensis* stage, the spirals being uniform, except just below the suture, where they are closely crowded. Intercalated spirals appear toward the end of these volutions.

The *conjunctus* stage is seen in the next whorl, which is, however, soon modified by having the whorl flattened laterally and so becoming cylindrical in form. This continues for a time, with an outward sloping shoulder, giving an appearance very unlike that of the French species. A strong senile feature is shown in the crowding together of the last added lamellæ, making a rough terminal portion of the last whorl, an irregular sutural shelf, and a pronounced posterior canal.

This specimen represents a case of extreme acceleration, the *rugosus* stage being practically dropped out, so that the earliest whorls of the conch are in the *damcriacensis* stage.

Horizon: Bracklesham (Middle) and Barton (Upper) beds of the British Eocene.

Localities: New Forest (M. C. Z. 27767) and Barton (M. C. Z. 27768); Hampshire.

CLAVILITHES CONJUNCTOIDES sp. nov.

(Plate VIII, fig. 19.)

General characters like *C. conjunctus*, but the preëphebic whorls strongly and coarsely ribbed and marked by spirals, and very unlike the regular ribs and spirals found in the Parisian species. The ribs are rather irregular and bulging in the center. The whorls embrace less than is the case with British species of this genus generally. The ribbed whorls are rather abruptly succeeded by smooth ones, which are at first rounded, but later have their sides flattened and sloping outward after the manner of *C. solanderi* and *C. egregius*. A faint shelf appears usually while the whorls are still round, thus showing an advance upon the French species. This shell is readily distinguished from the other British species by its strongly and coarsely ribbed spire. This distinguishes it also from the French species, from which it also differs in the loose spire with rather deeply impressed suture and the sloping sides of the body-whorl. It resembles most nearly some of the American species.

Locality: Brockenhurst, Hants Co., England (M. C. Z. 27794).
Horizon: Lower Oligocene Brockenhurst beds.

CLAVILITHES EGREGIUS (Beyrich).

(Plate XIV, fig. 2.)

1865. *Fusus longævus* var. *egregius* (Beyrich) von Koenen, Zeitsch. der Deutsch. Geolog. Gesellsch., Bd. 17, seite 479.
1889. *Fusus* (*Clavella*) *egregius* von Koenen, Norddeutsches Unteroligocän, pt. I, p. 206.
(See further *C. egregius* Beyrich below.)

The species of ribless *Clavilithes* found in the Brockenhurst beds was identified by von Koenen with Beyrich's *Fusus egregius*. While differing in some minor respects from the North German species, the two may, nevertheless, be considered specifically identical.

The protoconch is papillose and consists of several whorls. The succeeding whorls of the conch are at first globular, with well developed spirals, after which they become flattened in their upper portion, which instead of being parallel to the axis of the shell slopes outward at a strong angle. The lower part of the whorl is rounded, but that portion is covered by the succeeding whorl. The last whorl is smooth, the sides nearly parallel to the axis, and the suture with a very narrow shelf. The lip of the figured specimen flares out suddenly.

Locality: Brockenhurst, Hants Co., England (M. C. Z. 27793).
Horizon: Lower Oligocene (von Koenen), Brockenhurst beds.

CLAVILITHES SOLANDERI sp. nov.

(Plate XIV, figs. 5 and 6; Plate XV, figs. 1 and 2.)

1766. *Murex longævus* Solander, Brander Foss. Hants., pl. VIII, fig. 93. Not *M. longævus* Solander, ibid., pl. II, fig. 40, and pl. VI, fig. 73.
1812. *Fusus longævus* Sowerby, Min. Conch., vol. 1, p. 141, tab. 63, fig. 1.
1845. *Fusus longævus* Desor, Sowerby's Mineral. Conch., p. 99, pl. 46, fig. 1.

This species is distinct from all the French species which have been examined, though it is genetically related to them. It is larger, coarser and more robust than any of the Paris Basin species. So far as known it is confined to the British Eocene.

The protoconch is stout, its terminal whorls flattened so as to produce a trochus-shaped apex. It is papillose and consists of less than three volutions. No ribs have been observed. (See further description under *C. deformis.*)

The conch begins with a whorl somewhat larger than those of the protoconch and marked only by sharp and rather distant spirals. After this the whorls are thrown into transverse undulations, which in none of the specimens seen assume a true rib character. This continues for about a volution and a half, the whorls being rounded, and then, by a fairly sudden transition, the whorls become subconical, smooth and with

a sutural shelf. In one specimen (pl. XIV, fig. 6, M. C. Z. 1058) the spirals continue after the wrinkles cease, the whorl apparently still re-

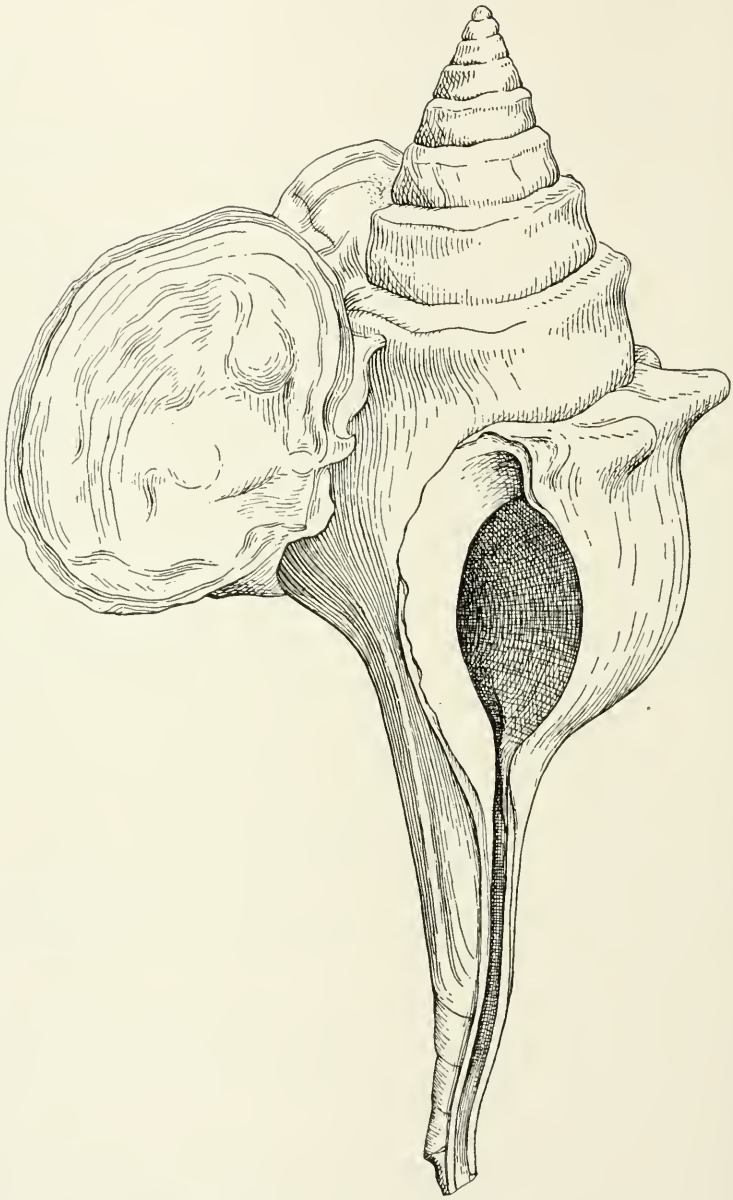


Fig. 16. *Clavilithes solanderi.* A gerontic individual (after Sowerby).

maining subglobular. In the succeeding whorls the depression seen below the suture of *C. conjunctus* is shown.

The subconic whorls continue to the end of the adult or ephebic

stage, as many as five volutions of this type having been noticed. They simply increase in size and in the width of the sutural shelf, but otherwise they do not change. The shelf is abruptly marked off from the whorl by a slightly acute angle, the shelf sloping inward.

The whorls are not absolutely smooth, spiral lines appearing faintly in the depression below the suture, as in *C. conjunctus*. In old-age individuals, this depression becomes stronger, and a projection of the sutural shelf is produced as in *C. longævus* Sol. The shelf in this stage also becomes somewhat more depressed, forming a modest sutural canal.

The increase in depth of the shallow depression below the shelf results in producing an outward bulge in the outer lip of the last whorl. This gives a curvature to the lip, which in younger shells is perfectly straight above.

A gerontic individual of this species is figured by Sowerby on plate 63 of his Mineral Conchology. This has about six volutions with a shelf, a little over five of which are of the normal type. The last, however, shows old age characteristics in the development of a spinous projecting rim of the shelf. This character is normal to the adult of the next species. The spinous prolongations are not true spines but simply irregular extensions of the shelf with a depression below the expansion. From the strong development of this depression the outline of the whorl has again become rounded. The accompanying illustration (fig. 16) is a copy of Sowerby's figure.

The distinctive characters of this species are produced by the appearance of the subconic shelved whorls immediately after the undulating spirally striate whorls which represent the *rugosus* stage. The species is in other words an excessively accelerated one, in which all the smooth round-whorled stages are dropped out. In the subconic form of the whorls this species is similar to *C. macrospira* Cossmann of the Parisian Eocene, and it is not impossible that the two may prove identical. The Parisian species is never so large and robust, and may represent a migrant from the British province into the Parisian one. From the difference of physical condition it did not thrive well in the Paris area, just as the migrant *C. parisiensis* from the Paris province did not thrive well in the British province, as indicated by the abnormal development.

Localities: Hampshire (M. C. Z. 1058, 1059); Barton cliff, Duval (M. C. Z. 1061 and 1060); same, Keeping (27762).

Horizon: Barton Beds. Upper Eocene.

CLAVILITHES LONGÆVUS (Solander).

(Plate XIV, fig. 8; Plate XV, fig. 3.)

1766. *Murex longævus* SOLANDER, Brander's Foss. Hant., figs. 40 and 73, not fig. 93.

This is the terminal species of this series, paralleling *C. scalaris* in the Paris Basin *Clavilithes*. These two species are generally considered identical, but their independent origin is established on inspection of the early stages of each.

There has been much confusion as to the true *Murex longævus* of Solander. For a long time the name *Fusus longævus* was applied to the type of the genus *Clavilithes,* which has been identified by Cossmann with Solander's *Murex deformis*. This identification I consider questionable, and I prefer to use Mayer's name *C. parisiensis*. Sowerby described and figured the fine example of *C. solanderi* here reproduced as typical *Fusus longævus*. Finally Mons. Cossmann identified Lamarck's *Fusus scalaris* from the Paris Basin with the typical British *C. longævus* (Sol.), calling all by that name. In this he is followed by all recent authors. The differences between these two species have been pointed out and their independent origin noted. Solander's description with omission of unimportant parts is here given, his illustrations are replaced by the more satisfactory photographs of characteristic specimens.

" . . . testa patulo-caudata lævi, anfractibus superne coarctatis supra planis, (adultioribus) margine obtuse spinosis."

"Testa crassiuscula, lævis, glabra, anfractus supremi transversim striati, omnes supra canali plano distincti, cujus margines in adultioribus obtuse, spinosi uti videre leceat in fig. 40 et 73."

"Cauda angustata, longitudine ipsius testæ."

"Apertura ovata."

The protoconch of this species is like that of *C. solanderi*.

The conch begins with two rounded, irregular and spirally striate whorls, the second of which has a few vertical undulations. This is the abbreviated *rugosus* stage. The *macrospira* stage* which follows immediately upon the *rugosus* as in *C. solanderi,* and which in that species characterized most of the whorls of the shell, is in this species very short with a few striations and a shelf, which soon becomes overhanging and spinose. The length of duration of this stage varies in different specimens, there being sometimes three or four volutions in which a shelf exists without a projecting rim. The beautiful regularity of the whorls of this stage, so characteristic of *C. solanderi,* does not appear in this species, the whorls being very irregular. The shelf is also more irregular, the surface not presenting that regular, gradually

* Whorls like *C. macrospira,* conical, with sides straight and sloping upwards, and with an abruptly delimited shelf.

widening path-like spiral which is the most pronounced feature of *C. solanderi.*

The spines, which generally appear quite early, become imbricating and coarse in the later whorls. The body whorl is semi-globular, as in the gerontic specimen of *C. solanderi,* and the spindle and canal long. A fold occurs just below the posterior canal, but becomes covered by the thickening of the canal.

Localities: Hampshire, Barton cliff (M. C. Z. 1062, 1063, Lyell, 27763, Keeping).

Horizon: Barton Beds, Upper Eocene.

This and the preceding species were also referred by some of the labels to the London Clay (Lower Eocene). This is probably erroneous.

No specimen of *C. parisiensis* has as yet been seen, which shows anything but the loss of characteristics in its gerontic stage. By the loss of the shelf the species assumes again the characters peculiar to the more primitive *C. conjunctus.* In the gerontic stage of *C. solanderi* we have, on the other hand, a distinct addition, a new character, spines, being developed in the old age of the individual. The succeeding species, *C. longævus,* has this newly acquired character developed to the exclusion of almost all the other characteristics. The character is a newly acquired one in the old age of the earlier individuals, and it has not only become inherited in the succeeding species, but, in obedience to the law of acceleration, has been pushed back into the youthful stages of the shell.

No specimen of *C. subscalaris* with the *scalaris* features in the gerontic stage have as yet been seen. From analogy with *C. solanderi,* and from theoretical considerations, we should expect to find *scalaris* features appearing in extreme old individuals of *C. subscalaris.*

There is a remarkable parallelism between the young of typical species of *Clavilithes,* like those of the Paris Basin, and that of *Turbinella chipolana* Dall from the Tertiary of Chipola River, Calhoun County, Florida. Other species of *Turbinella* whose young are very similar to *Clavilithes* are *T. regina* Heilprin and *T. scolymoides* Dall, both from the later Tertiaries of Florida. Externally scarcely any difference can be seen between the young *Turbinellas* and the young *Clavilithes.* The protoconch of the former is perhaps somewhat larger, but that is not always the case. Often it shows a slight angularity, which recalls the protoconch of *"Fusus" probocidiferus.* The character of the ribs and spirals on the young conch are also closely similar to those of young *Clavilithes.* The three strong columellar plications, which are seen even in the young of *Turbinella,* and the elongated character of the lip, which recalls *Rhopalithes noæ,* are, however, pronounced differences. In the youngest shells of *Turbinella* seen the upper of the three plications is very weak.

These species of *Turbinella* run in a general way through the same series of variations as do those of *Clavilithes*, but no shoulder has been observed.

Clavilithes in the North German Oligocene.

CLAVILITHES EGREGIUS (Beyrich).

(Plate XIII, fig. 12.)

1856. *Fusus egregius* Beyrich, Zeitsch. Deutsch. Geol. Gesell., Bd. VIII, p. 78, pl. 22, figs. 1–5.

1889. *Fusus* (*Clavella*) *egregius* v. Koenen, Norddeutsches Unter-Oligocän, Lief. 1, p. 206, pl. 20, fig. 11.

A single specimen of this species has been seen in which the protoconch and early whorls of the conch have been broken away. None of the remaining whorls are ribbed, and apparently none of the earlier whorls were. The first four whorls are spirally striate, the first two globular with simple spirals, the next two with intercalated spirals and the form turbinate, *i. e.*, the greater portion below the suture being flat, not convex. The lower part is abruptly deflected inward. The last whorl is smooth. Beyrich figures several large and fine specimens of this species, which rival in size the Parisian forms, without, however, equalling the British. The last whorls remain smooth and of a somewhat rounded contour, the turbinate aspect of the young being lost. This and the absence of the shelf show that this species has not passed beyond the *conjunctus* stage. The *rugosus* stage is dropped altogether, the species beginning with the *dameriacensis* stage. The protoconch is papillose but the terminal portion seems to be somewhat coarser than that of the normal Parisian forms.

The turbinate aspect of the young is caused by the fact that the later whorls embrace the earlier ones up to the middle.

Localities: Wolmirsleben (M. C. Z. 1114); Westeregeln, Atzendorf and Welsleben, North Germany (Beyrich); Lattorf, Calbe, Atzendorf, Unseburg, Welsleben, Westeregeln, Osterweddingen, Helmstädt; Lethen; North Germany. Also Brockenhurst Hants. England (von Koenen).

American Species of Clavilithes.

The American (Gulf Coast) species which are generally referred to the genus *Clavilithes* offer a surprising parallel to those of the Paris Basin. There are, however, distinct features which persist throughout the entire series and which might perhaps be considered as sufficient to demand separation of this series under a distinct generic name. The chief of these features are the loose coiling, the broad ribs of the preephebic stages, and the character of the protoconch. The latter is very irregular and when perfect presents a slight upward projecting apex, very different from that of the Paris Basin species which has a termination consisting of a minute naticoid whorl with rounded apical end. The apical whorls of the American species are furthermore laterally

compressed as is the case with the species of the British series, thus producing a trochus-shaped apex.

For the present I will leave these species under the generic designation of *Clavilithes,* but with the understanding that they form a distinct series, which may have originated independently.

CLAVILITHES PACHYLEURUS (Conrad).

1842. *Fusus pachyleurus* Conrad, Journ. Phil. Acad. Nat. Sci., vol. 8, p. 190.
1848. *Fusus pachyleurus* Conrad, ibid., 2d ser., vol. I, pl. 14, fig. 25.
1865. *Clavella pachyleurus* Conrad, Am. Journ. Conch., vol. I, p. 18.
1890. *Fusus (Clavella) conjunctus* var. *pachyleurus* Gregorio, Ann. de Geol. et de Pal., Liv. 7, p. 89.
1893. *Clavilithes pachyleurus* Cossmann, ibid., Liv. 12, p. 36.

This species is the American equivalent of the Parisian *C. conjunctus.* The early whorls are rather bulging with closely set ribs, the spaces between which are concave and scarcely equal in width to the ribs. The whole aspect of the shell is stouter and more compact than that of *C. humerosus* (pl. VIII, figs. 17, 18), and not unlike that of *C. conjunctus.* The depressions between the ribs are often mere lines. Each whorl embraces about one third of the preceding one, and the ribs are continuous from suture to suture. The shelf is practically undeveloped.

Localities: Clayborne, Alabama (Acad. Sci. 6912; Nat. Mus. 90921).

Horizon: Eocene (Claiborne beds).

CLAVILITHES HUMEROSUS (Conrad).

(Plate VIII, figs. 17, 18.)

1856. *Clavella humerosus* Conrad, Proc. Acad. Nat. Sci., vol. 7, p. 259.

This species in its adult character is a close parallel to *Clavilithes parisiensis* of the Paris Basin. It differs from that species in the characters which distinguish the American species generally from those of the Paris Basin. The protoconch is very irregular with more or less oblique whorls, a trochoid apical portion, and a projecting apical point. The last whorls have a few faint and distant riblets, and extremely fine revolving lines. There is no abrupt termination.

The conch in its early whorls has rounded distant ribs swollen in the middle, and with numerous revolving spirals, which are simple for the first three volutions and then become increased by intercalation. A slight subsutural band indicates a posterior canal. About four and one half volutions are ribbed, and the sutures are deeply impressed. The ribs become mere undulations towards the end of the stage, after which one or more whorls of the *conjunctus* type with rounded shelfless contour and smooth surface succeed. A few spirals may be retained on the early portions of these whorls, thus forming a *dameriacensis* stage. The shelf makes its appearance gradually and the contour of the whorl becomes cylindrical. This outline is fully assumed only

when the shelf is completely developed. The shelf generally slopes inward more as in *C. solanderi* of the British series.

Localities: Jackson, Miss. (Acad. Sci. 6884, Conrad's types) (M. C. Z. 27792) (Nat. Mus. 14707); Mount Lebanon, La. (Acad. Sci. 6887, Nat. Mus. 147318, 147316); Montgomery, La. (Acad. Sci. 6886); St. Maurice, La. var. (Acad. Sci. 6885).

Horizon: Jackson stage, Eocene (var. Claiborne stage).

Note: The last-mentioned variety has less impressed sutures between the whorls, and the shelf appears early, the *conjunctus* stage being much condensed or almost eliminated. The convexity of the whorls is suppressed, so that the sides appear almost straight, though converging upwards. The shelf is narrow and regular. The ribs of the neanic stage are narrower, more uniform and less bulging. The protoconch is of the usual type. The other Louisiana specimens form connecting links, and together these forms lead to the Texan variety next described.

CLAVILITHES TEXANUS Harris.

1896. *Clavilithes humerosus* var. *texanus* Harris, Proc. Phil. Acad. Nat. Sci., 1895, p. 73, pl. 7, fig. 7.

This species is a parallel to the Parisian *C. subscalaris, i. e.,* it is in the same state of development. As in the other species of this series, the first whorl of the protoconch is abruptly compressed and somewhat elevated so as to produce a strong projecting point. The other whorls are round.

The neanic whorls of the conch are similar to those of the variety from St. Maurice, La. In the later whorls the spirals become subdued. The shelf appears early and a slight depression forms below it, recalling the deep concavity characteristic of *C. chamberlaini* Johnson and Grabau.

Locality: Alabama Bluff, Trinity River, Houston Co., Texas (Acad. Sci. 6889); Claiborne, Alabama (Nat. Mus. 2916).

Horizon: Eocene (Claibornian).

CLAVILITHES RAPHANOIDES (Conrad).

1834. *Fusus raphanoides* Conrad, Journ. Acad. Nat. Sci., vol. 7, p. 144.
1835. *Fusus raphanoides* Conrad, Foss. Shells Tert. Form. N. Am., p. 54, pl. 18, fig. 8.
1890. *Fusus* (*Clavella*) *raphanoides* Gregorio, Ann. de Geol. et de Pal., Liv. 7, p. 89.
1893. *Clavilithes raphanoides* Cossmann, ibid., Liv. 12, p. 36.

"Fusiform, entire; whorls slightly contracted above; suture profound; margined by an obsolete raised line; body whorl abruptly rounded inferiorly; aperture suddenly contracted above and beneath" (Conrad).

This species recalls *C. egregius* from the North German Oligocene in its final whorls. Spirals seem to be absent altogether from this species.

Locality: Claiborne, Alabama (Conrad) (Nat. Mus. 2973).
Horizon: Eocene, Claibornian.

CLAVILITHES VICKSBURGENSIS (Conrad).

1849. *Clavella vicksburgensis* CONRAD, Journ. Phil. Acad. Nat. Sci., ser. 2, vol. I, p. 207.
1850. *Clavella vicksburgensis* CONRAD, ibid., vol. II, pl. I, fig. 5.

"Fusiform, smooth, moderately thick; spire conical, with obtuse longitudinal remote varices, first and second volution entire; suture impressed; body whorl regularly rounded towards the beak; aperture and canal about one tenth longer than the shell; beak straight and pointed 2¼ : ¾."

"*Locality:* Vicksburg, Mississippi, abundant."

A few faint undulations appear near the top, but otherwise the shell is smooth and recalls *C. egregius*.

Horizon: Vicksburg stage, Lower Oligocene.

CLAVILITHES KENNEDYANUS Harris.

1895. *Clavilithes kennedyanus* HARRIS, Proc. Acad. Nat. Sci. Phil., p. 73, pl. 7, fig. 8.
1899. *Clavilithes kennedyanus* HARRIS, Bull. Am. Pal., vol. III, p. 44, pl. 5, fig. 8 (variety). (See fig. 17.)

This is a slender species with the spire tapering to a very acute point. It has somewhat the aspect of a *Clavellofusus*. No fully preserved protoconch has been observed. It consists apparently of three or more rounded whorls, loosely set one upon the other. The ribs of the conch are at first of uniform strength throughout, but later they become stronger in the middle and obsolete towards the sutures. They are at first separated by a space much more than their width apart, then grow broader, with narrowing interspaces. A slight revolving concavity occurs just below the suture. The ribs disappear on about the sixth whorl of the conch, after which the whorls are convex and smooth, the spirals being scarcely visible. The last of the smooth whorls embrace the preceding ones up to the suddenly constricted base of that volution, thus giving the spire a uniform tapering aspect.

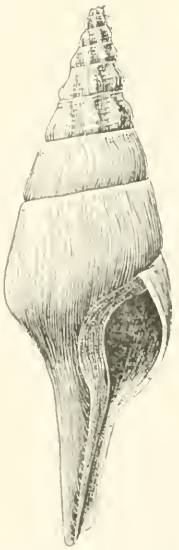


FIG. 17. *Clavilithes kennedyanus*. (After Harris.)

Localities: Woods Bluff, Ala. (Acad. Sci. 6914); near Thomasville and Choctaw Corner, Alabama (Nat. Mus. 8885); Nanafalia, Ala., and Smithville, Bastrop Co., Texas (Harris).

Horizon: Eocene, Lignitic and Lower Claiborne stages.

CLAVILITHES CHAMBERLAINI Johnson and Grabau.

1901. *Clavilithes chamberlaini* Johnson and Grabau, Proc. Acad. Nat. Sci. Phil., Nov., 1901, p. 602, figures in text.

Fig. 18. *Clavilithes chamberlaini* type. (After Johnson and Grabau.)

This species is the structural equivalent of the Parisian *C. scalaris* and the British *C. longævus.*

The spire of this species is long and slender, as in *C. kennedyanus* Harris, with which the early whorls of the shell agree pretty well. Only a portion of the protoconch has been observed, but it is apparently of the same character as that of the American species of this genus generally, unless more slender than the normal. The spire contains about seven ribbed whorls; the suture is moderately depressed; the ribs are swollen near the middle, but become obsolete toward the suture; they are at first more than their width apart, but later become broader and the interspaces correspondingly narrower. A subsutural band occurs, and is quite strongly marked on the later ribbed whorls, indicating a pronounced posterior canal at this stage.

Spirals on the first five whorls, single, coarser in the center, but becoming finer toward the sutures; interspiral spaces broader than the spirals. Intercalation of secondary spirals begins on the sixth whorl. On the seventh whorl the ribs become broad and ill defined, tending toward obsolescence. Before they have quite disappeared, a sutural shelf sloping somewhat outward and bordered by a slightly outward projecting margin appears; this very soon develops into a serrated flange. At the same time the whorls become almost smooth, the spirals usually only occurring on the narrowed anterior portion or canal of the body whorl. Length of the adult specimen figured 39 mm., diameter 18 mm.

Fig. 19. *Clavilithes* sp. An immature individual in the rugosus stage. It probably belongs to a species which never passes far beyond this stage, and thus is ancestral to both *kennedyanus* and *chamberlaini.*

Compared with *C. humerosus* var. *texanus* Harris it has more ribs on the spire, and these are more regular and bulging, stronger spirals, and the well-marked serrated flange. It also differs somewhat in outline, the last whorl being broader than the corresponding whorl of *texanus.* It differs from its European parallels in many characters, chief of which are the protoconch, the long ribbed spire, the character of the sutural shelf and flange, and other points readily seen on comparison.

Locality: Bald mound, nine miles southeast of Jewett, Leon Co., Texas (Acad. Sci. 9409).

Horizon: Eocene, Lower Claibornian.

CLAVILITHES (?) SALEBROSUS (Conrad).

1834. *Fusus salebrosus* CONRAD, Journ. Acad. Nat. Sci., vol. 7, p. 145.
1835. *Fusus salebrosus* CONRAD, Foss. Shells Tert. Form. N. Am., p. 55, pl. 18, fig. 13.
1835. *Fusus protextus* CONRAD, ibid., p. 54, pl. 18, fig. 7.
1866. *Fusispira protexta* and *salebrosa* CONRAD, Check list, p. 19.
1890. *Fusus* (*Fusispira*) *protextus* and *salebrosus* GREGORIO, Ann. de Geol. et Pal., Liv. 7, p. 90.
1893. *Clavilithes protextus* COSSMANN, ibid., Liv. 12, p. 36.

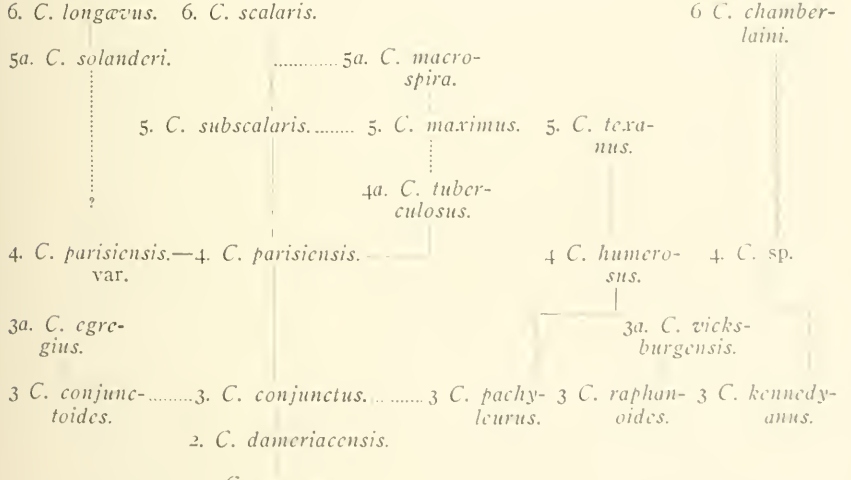
Conrad's *F. protextus* is the adult of his *F. salebrosus*. The ribs of the early whorls are chiefly restricted to the peripheral portion, the shoulder being flat or slightly concave and ribless. Spirals persist throughout. The last whorl or more is entirely ribless but with a pronounced concavity on the shoulder. There is no sutural shelf.

It is not unlikely that this species belongs to another series (*Fusispira* Conrad).

Locality: Claiborne, Alabama (Conrad).

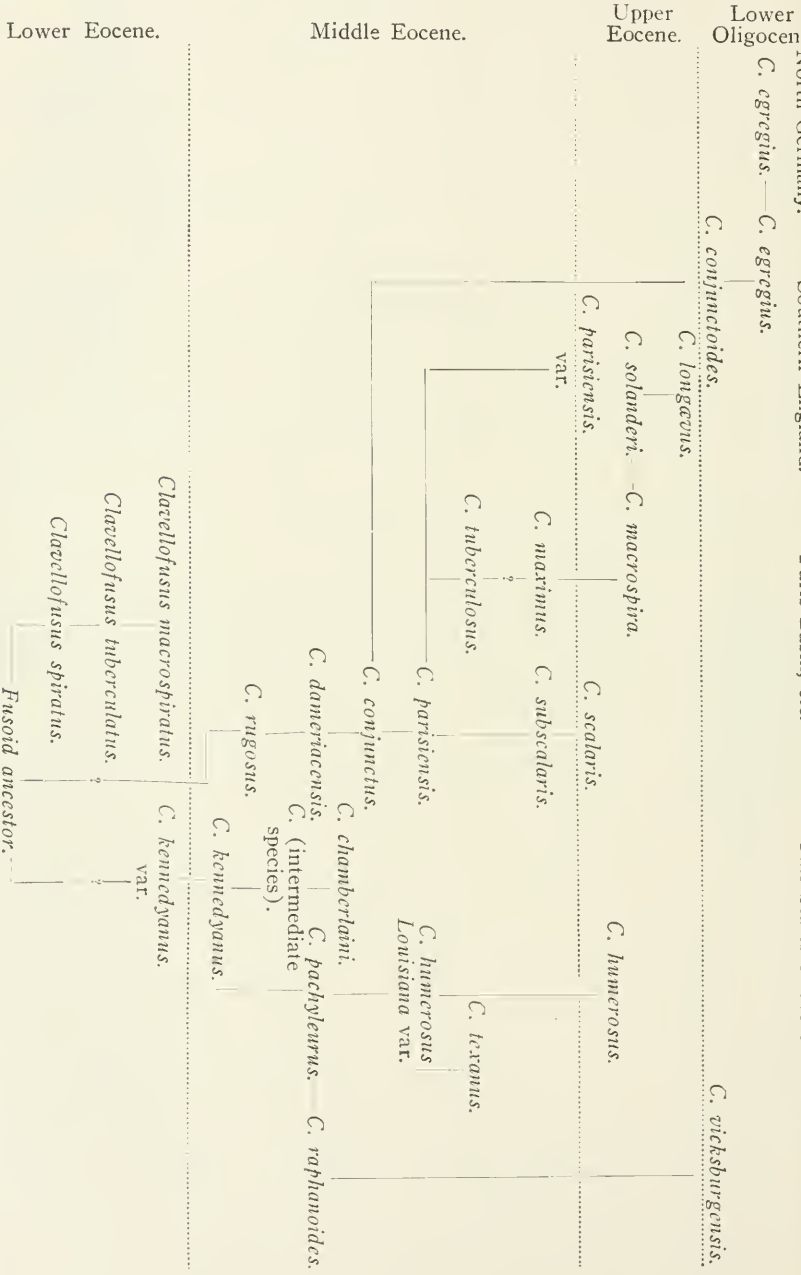
Horizon: Eocene, Claibornian.

The following table shows the biologic equivalency of the various species here described under the generic designation of *Clavilithes*. The structural equivalents, *i. e.*, those in the same stage of development are placed upon the same line:



The dotted lines indicate doubtful relationship.

The following table shows these species in their geologic and biologic relations with the probable origins and migrations indicated. The species of *Clavellofusus* are also shown.



RHOPALITHES * gen. nov.

(*ῥόπαλον*, a club; *λίθος*, stone.)

Shell fusiform with a fusoid protoconch, consisting of a smooth erect portion, of about a whorl or over, and a vertically ribbed portion, with the fine smooth ribs widely separated. The conch consists of ribbed and spirally striate whorls, which are rather closely coiled, followed in the more accelerated species by smooth whorls, which generally develop the Clavilithoid shelf. The columella is furnished with two or more oblique plications.

Distribution: Eocene of Paris Basin; Adour basin; Northern Italy, etc.

Genotype: Fusus noæ Lamarck.

RHOPALITHES RUGOIDES sp. nov.

(Plate IX, figs. 9–12.) (Type Plate IX, fig. 10 and text fig. 20.)

1837. *Fusus rugosus* var. DESHAYES, Coq. Foss. Env. Paris, pl. 75, figs. 10, 11.

The protoconch of this species is fusoid, obliquely erect and consists of a volution and a half. The greater portion is smooth, but toward the end it is marked by a few fairly strong smooth ribs which are several times their width apart. There are no spirals between the ribs. The protoconch ends in a marked varix, and there is a pronounced change in convexity and ornamentation.

The conch begins with strongly ribbed and spirally striate whorls, on which the ribs are widely separated. The whorls embrace about one third or a little more, thus producing a very depressed spire. A considerable flattening of the shoulder and a strong peripheral angulation results. The ribs increase in strength toward the periphery where two of the spirals are strong. These are soon reënforced by a third, and all three produce blunt cusps at the intersections with the ribs. In the adult or ephebic stage the whorls become again more rounded though the shoulder is still flattened, the ribs are round and obtuse, and a faint subsutural band exists, indicating a posterior canal. Two well-marked plications occur on the columella.

FIG. 20. *Rhopalithes rugoides*, showing protoconch. (× 10, M. C. Z. 27777.) (See pl. IX, fig. 10.)

This species is the parallel of *Clavilithes rugosus*, with which it is commonly united. While generically distinct it shares with *C. rugosus* the specific characteristics and hence is to be regarded as the *rugosus* type of this generic series.

Localities: Paris Basin (M. C. Z. 27776, 27777, Bronn, 1376. Duval; 27780 Koninck); Grignon, (M. Z. 27779, Duval); Ully, St. Georges (Acad. Sci. 8027); Damery (Am. Mus. Nat. Hist.).

Horizon: Eocene (Middle, Cossmann).

Additional Remarks.—From the beginning of the conch the whorls are marked by strong vertical ribs which bulge at the center where the

* *Rhopalolithes* would be more satisfactory to purists but is less euphonious.

two stronger spirals occur. On some specimens the earliest whorls appear somewhat more rounded than in specimen fig. 20, but the succeeding whorls are angular from the strong development of the two central spirals.

Where the two central spirals cross the ribs, a flattened node of rather sharp character is formed, precisely as in the neanic whorls of *Falsifusus serratus,* where one node occurs, or as in *Fusus asper,* where three nodes are found. In some specimens the next spiral above approaches the main spirals in distinctness, a peripheral tricarination being thus produced. Above this the spirals decrease gradually in size toward the suture, while intercalated spirals may or may not occur. The spirals are often crowded. The shoulder is often slightly concave and the subsutural band accentuates the concavity.

Below the peripheral angulation the spirals are more uniform and subequally spaced, while intercalated spirals occasionally appear. The angular appearance of the periphery is lost in the last whorl by the increase in strength of the other spirals. In more accelerated specimens the rounded contour of the body whorl is accentuated by the faint character of the spirals, as well as the obsolescence of the ribs. A thickening of the subsutural band produces contours characteristic of *R. noæ.* This feature is particularly marked in accelerated individuals.

A crowding of the lines of growth often produces a rough cancellation of the spirals.

In a specimen in the collection of the Philadelphia Academy of Sciences the protoconch, though swollen, is more depressed than in the other specimens seen. It resembles in this respect somewhat that of *Fasciolaria.* Toward the end of the first volution are faint indications or riblets, these becoming strong and closely set on the last part of the protoconch. They then become stronger and further apart and finally appear to merge into the normal ribs of the shell. The two plications on the columella are not well preserved, owing to the chalky character of the shell.

RHOPALITHES ANGULATUS (Lamarck).

(Plate IX, figs. 14–17.)

1803. *Fusus angulatus* LAMARCK, Ann. du Museum, T. 2, p. 385.

1837. *Fusus angulatus* DESHAYES, Coq. Foss. Env. Paris, tome 2, p. 520, pl. 74, figs. 11, 12.

The protoconch of this species closely resembles that of the preceding one, being obliquely erect, smooth in the early portion, but with smooth riblets in the last part. In this, as in the preceding species, there are only two of the protoconch riblets in the most typical specimens.

The conch begins with whorls in which the angulation is but slightly marked and which are furnished with rounded ribs and subequal spirals. This quickly merges into angular whorls, in which two spirals

become prominent on the periphery while the shoulder is marked by numerous fine uniform spirals, the primary ones being augmented by intercalated secondary ones. On the body of the whorl the spirals are coarse and distinct. The intercostal spaces become more and more concave, giving an undulatory instead of simply ribbed character to the surface.

In the nepionic stage this species has the character of neanic or early ephebic *R. rugoides*, this being well shown in the young specimens in figs. 14 and 15, pl. IX. Since the adult characters of *R. rugoides* show a development in the direction of the *R. noæ* type, *i. e.*, the suppressing of ribs and angularity of whorl, it is evident that if *R. angulatus* is an offshoot from *R. rugoides*, its relationship is with the more primitive varieties of that species.

The gerontic stage of *R. angulatus* has been seen in a few specimens (M. C. Z. 1382, pl. IX, fig. 21). These are large for the species, and the last whorl reaches up onto the preceding with the formation of a strong posterior sinus. In the last part of the whorl the tubercles are crowded and the strong asperations have become subdued. In another specimen (M. C. Z. 1377) the last whorl has a rounded contour, the angulation having disappeared. The ribs are round and extend over the entire surface as in a mature *R. rugoides*. The posterior canal is deep and strongly marked, and the subsutural band is very prominent. On the shoulder the spirals are fine, numerous and regular. On the body they are coarse and distant.

This individual is transitional to *R. clavelloides*, which is phylogerontic.

All the specimens examined, normal or accelerated, show two strong oblique columellar plications. These are best seen on specimens with broken outer lip, as they are only developed some distance back of the aperture. In gerontic types they apparently become obsolete, or at least are found only far back on the columella.

Localities: Paris (M. C. Z. 1384, Baucoult, 1382, Koninck, 1377, Duval); Grignon (1381, Agassiz, 1385, Duval, both M. C. Z.); Montmiraille (M. C. Z. 1383).

Horizon: Middle Eocene: Calcaire Gross. (Cossmann). Upper Eocene: Sables Moyens (Desh.).

RHOPALITHES CLAVELLOIDES sp. nov.

(Plate IX, fig. 22.)

1837. *Fusus angulatus* var. DESHAYES, Coq. Foss. Env. Paris, t. 2, p. 521, pl. 73, figs. 4, 5.

This species holds the same relation to *R. angulatus* that *R. noæ* does to *R. rugoides*. The last whorl is almost smooth, having lost its ribs, which are only represented by faint undulations. The sutural shelf

characteristic of all the phylogerontic species of this and related series is well developed, and the sides are parallel to the axis of the shell. We have in this series the shelved stage following immediately upon the *rugosus* stage, the latter being represented by the *R. angulatus* type of whorl. This was already noted by Deshayes, who stated that the early whorls of this variety were precisely like those of *R. angulatus*. Two plications occur on the columella. In the specimen figured the ribs still persist as undulations but the spirals are obsolete. In the figure given by Deshayes (pl. 74, figs. 4–5) the ribs have disappeared, but the spirals are still strong. These specimens show different degrees of acceleration.

Localities: Paris Basin (M. C. Z. 1393); Grignon (Desh).

Horizon: Eocene (Upper?).

RHOPALITHES TUBERCULOIDES sp. nov.

(Plate IX, figs. 23, 24.) (Type fig. 24.)

This species occupies the position in the present series which *C. tuberculosus* occupies in the *Clavilithes* series. From five to six whorls have the characters of *R. rugoides*, having all the features found in that species. These are followed by one or more whorls which are free from ribs, and only faintly marked by spirals, these gradually becoming obsolete. These whorls are rounded in outline and furnished with a well-developed sutural shelf which slopes gently outward as in the majority of species of *Clavilithes*. In the specimen, fig. 23, which is somewhat more accelerated than the type, this shelf appears while the shell is still ribbed, thus paralleling some of the more highly accelerated species of *Clavilithes*. The posterior canal is strongly developed, and a pseudo-umbilication is produced by the separation of the inner lip from the columella.

Two young specimens of this series are in the *subtuberculosus* stage (pl. IX, figs. 18, 19). The first of these is only a step more advanced than the specimen of *R. rugoides* figured on plate IX, fig. 12, in which the last whorl shows a subduing of ribs and spirals and a general rounding of the contours. In fig. 18 the ribs have entirely disappeared but the spirals remain. The sutural shelf is moderately developed and the columella is doubly plicate. The other specimen (fig. 19) is somewhat more accelerated, the *rugosus* stage is shorter and the *subtuberculosus* stage is more strongly developed, occupying a complete volution. Two columellar plications occur. It is, of course, impossible to state whether these are the young of *R. tuberculoides* or of a form in which a *parisiensis* stage succeeds the *tuberculosus* stage, *i. e.*, *R. noæ*.

A specimen from Ully, St. Georges (Acad. Sci. 8026), shows the characters of *R. tuberculoides*. The last whorl is rounded, without

ribs but with a shelf and a slight depression or concavity below this. The spirals are strong. The penultimate whorl is similar, but without the shelf. Four distinct plications are seen far back on the columella. The subsutural band is prominent.

Another specimen from Parnes in the same collection (6897) is quite remarkable, in that it retains its ribs even onto the final whorl. The last of the ribbed whorls have a well-developed sutural shelf. The spirals also remain strong. This is a case of partial acceleration in which some of the features which normally should have disappeared are still present.

Localities: Paris Basin (M. C. Z. 1397, 27784, 27774, 1390, 27728, type); Ully, St. Georges (Acad. Sci. 8026); Parnes (M. C. Z. 27788, Acad. Sci. 6897); Chaussy (Amer. Mus.).

Horizon: Middle Eocene.

RHOPALITHES NOÆ (Chemnitz).

(Plate XVI, figs. 1–8.)

1795. *Murex noæ* Chemnitz, Conch. Cabin., vol. XI, p. 296, pl. 212, figs. 2096, 2097.
1803. *Fusus noæ* Lamarck, Ann. du Museum, t. II, p. 317.
1815. *Fusus noæ* Lamarck, Tab. Encycl. Meth., pl. 425, fig. 5.
1823. *Fusus noæ* Lamarck, Rec. de Planches des Coq. Foss. Env. Paris, pl. IV, figs. 1, 2.
1824. *Fusus noæ* Deshayes, Coq. Foss. Env. Paris, T. II, p. 528, pl. 75, figs. 8, 9, 12, 13.
1866. *Fusus noæ* Deshayes, Anim. sans Vert., p. 257.
1889. *Clavilithes noæ* Cossmann, Cat. Coq. Foss. Env. Paris, p. 174.
See also:
1896. *Fusus* (*Clavella*) *noæ* var. *orangustatus* Gregorio, Ann. de Geol. et de Pal., Liv. 21, p. 45, pl. 4, fig. 14 *a–c*.

This species is the parallel of *Clavilithes subscalaris*. It always possesses a *rugoides* stage, the young being indistinguishable from *R. rugoides*. This stage varies in the number of whorls which it possesses, these being fewer in the more accelerated individuals. There is also some variation in the strength of the ribs and the angularity of the periphery of the whorls which is often accentuated by the strengthening of the peripheral spirals and the concomitant retention of the shoulder striæ. The strong development in accelerated individuals of the subsutural band gives the shoulder a concave appearance which further accentuates the angularity of the periphery. These variations are of the same character as those found in *R. rugoides*.

One of the characteristic features of *R. noæ* is the persistence of the spirals on the body-whorl after the acquisition of the adult characteristics. On the whorl itself they are somewhat subdued, but on the spindle they are as a rule very strong.

The specimens illustrated on plate XVI show some of the chief varieties of this very variable species. These varieties owe their

origin to differential acceleration, and they present parallels to the varieties of *C. subscalaris*. Fig. 1 has a well-marked *tuberculoides* stage with rounded ribless whorls which are strongly spiralled and have a pronounced sutural shelf. This stage passes into the true *noæ* stage with cylindrical whorl, strong slightly outward sloping shelf, subdued spirals, and an elongated pyriform aperture with a pronounced square posterior canal. The *rugoides* stage occupies about four or five whorls, the last of these with faint broad ribs and a strong subsutural band. The columellar plications are scarcely visible, owing to the fact that they occur far back on the columella. They may be seen, however, in broken specimens.

Fig. 2 shows a more accelerated individual in which the *tuberculoides* stage is almost wholly crowded out. The ribbed spire (*rugoides* stage) is long, occupying about six whorls. With the disappearance of the ribs the cylindrical form is assumed, the shelf passing into the *noæ* stage. On this the shelf slopes strongly outward. The columellar plications are faintly visible.

Fig. 3 shows a young specimen which has barely passed beyond the *rugoides* stage. This latter is of very short duration and strongly spiralled. The shelf just appears on the last ribbed whorl, there being nearly a complete volution of that type. The *tuberculoides* stage is well developed. The two columellar plications are well shown as the lip is slightly broken. It appears, furthermore, to be characteristic that the columellar plications are nearer the lip in the young and the primitive species than in the adult or the accelerated species.

In fig. 4 the shelf does not appear until after the ribs have disappeared, thus producing a short stage comparable to the *subtuberculosus* stage of the *Clavilithes* series. This indicates that this individual is less accelerated than the majority of shells of this species.

A somewhat similar condition is shown in fig. 6 and to a very slight extent in fig. 8. In the latter individual the *tuberculoides* stage next succeeding is very short, being almost crowded out and replaced by the *noæ* stage. In the last whorls of this stage a rather pronounced projecting rim occurs which recalls the characteristics of *Clavilithes scalaris* to the more primitive specimens of which this is a parallel. It also forms a transition to *R. japeti,* the terminal member of this series.

Fig. 7 shows considerable acceleration in that the sutural shelf occurs in the last two ribbed whorls. Indications of the presence of the two columellar plications have been obtained in all the specimens illustrated except figs. 7 and 8. The first of these is a very old individual, and although the lip is broken the plications appear to be so far back as not to be visible.

In senescent individuals the inner lip is separated from the columella and an umbilication is produced. In specimens where the outer lip is broken away sufficiently, the columellar plications will show, even

in extremely old individuals. In some highly accelerated types the *tuberculoides* stage is dropped out, the *noæ* following directly upon the *rugoides* stage, the shelf often appearing in the latter stage.

Localities: Paris Basin, numerous localities, including Chamery Grignon, Montreville, etc. (M. C. Z. 1101, 1103, 1104, 1106, 1112, 1131, 1396, 27726, 27727, 27789–27791); Ronca (De Gregorio); Grancona, Italy (Oppenheim); "Eocaen von Nizza und Ungarn" (Oppenheim).

Horizon: Eocene, Calcaire Grossier, chiefly middle. Erratic in Sables Moyens, Upper Eocene (Deshayes).

In the collection of the American Museum (Zit. 847) are several specimens from Chaussy, France, which in ornamentation have never passed beyond the *rugosus* stage. The ribs persist to the end though the specimens are large. The last whorl has a shelf. The specimens resemble *R. clavelloides* of the *angulatus* branch (pl. IX, fig. 22) though they belong to the *R. noæ* series. In all specimens the two plications on the columella are shown. In somewhat more advanced specimens ribless whorls succeed.

This is a case of retardation in development, the primitive stage being retained long (*i. e.*, the ribs), so that the shelf appears before the ribs are lost. It is not a primitve form but a retarded advanced form.

RHOPALITHES JAPETI (Tournouer).

1873. *Fusus japeti* TOURNOUER, Bull. Geol. Soc. France, 2d ser., T. 29, p. 501, tab VI, fig. 7.

1897. *Fusus japeti* TOURNOUER, Vinassa di Regny. Palæontographica Italica, III, p. 193, tav. 20, fig. 36 *a, b.*

1901. *Fusus japeti* TOURNOUER, Oppenheim Palæontographica, vol. 47, p. 216, taf. XXI, fig. 17. (See fig. 21.)

This is the terminal species of this series, holding the same relations to the preceding species that *Clavilithes scalaris* holds to the other members of that series from the Paris Basin. The best figure is that given by Oppenheim, which is here reproduced.

FIG. 21. *Rhopalithes japeti* slightly reduced. (After Oppenheim.)

The nepionic whorls are round, with broad rounded ribs separated by less than their width. A narrow but strongly marked subsutural band occurs as in *R. noæ*. The spirals are strong and numerous and appear to be all of the same size.

The ephebic whorls are smooth or but faintly marked by the spirals, except on the spindle where the spirals are strong. The shelf is very pronounced and below it is a strong groove or spiral depression. The margins of the shelf are turned upwards like the rim of a saucer. The long persistence of the *rugoides* whorls shows that the species is terminal only to a retarded branch of the series.

Oppenheim says of this species: "Die Form steht in der Mitte zwischen *Cl. Noæ* einer, und *Cl. longævus* Sol. (= *Cl. scalaris* Lam., Cossmann, Cat. IV, p. 172) anderseits; von der ersten Art besitzt sie die etwas schwächeren aber immer noch hervor tretenden Spiralen, von der letzten den rampenartigen Kiel an den letzten Windungen."

Tournouer's figure shows a less pronounced type. The spirals are stronger but the shelf is less projecting. The spiral depression below the shelf exists, however, and the preëphebic stages are *noæ*-like.

This is an important and common species in the fauna of the "Blaue Märgel" near Pau on the borders of the Pyrennees—degli Orti, Val Orcagna, Castelcies, Onigo) Northern Italy (Oppenheim).

COSMOLITHES gen. nov.

The species of this genus are fusoid shells with ribbed and spirally striate whorls which in some species become smooth toward the end. The protoconch is depressed and naticoid, consisting of about one and one half volutions. The greater portion is smooth, but toward the end are a number of fine, smooth and uniform, vertical riblets. A moderate varix marks the end of the protoconch. Columella plaited with one prominent plait, and in some specimens with an additional fainter one.

This genus differs from *Rhopalithes* in its depressed naticoid protoconch, with numerous riblets, and in its single strong plication. The differences are constant and important. These features indicate some relation to *Fasciolaria.*

Genotype: Fusus uniplicatus Lamarck.

COSMOLITHES UNIPLICATUS (Lamarck).

(Plate IX, figs. 13, 20; Plate XIII, figs. 1–3.)

(Figures 22 and 23.)

1803. *Fusus uniplicatus* LAMARCK, Ann. du Mus., T. II, p. 385.

1823. *Fusus uniplicatus* LAMARCK, Receuil Planch. Coq. Foss. Env. Paris, pl. 4, figs. 3 *a, b.* (Ann du Mus., pl. 6, fig. 3 *a, b.*)

1824. *Fusus uniplicatus* DESHAYES, Coq. Foss. Env. Paris, p. 536.

The protoconch of this species consists of one and one half volutions, is depressed, naticoid, the apex minute, but gradually enlarging throughout. The last portion of the protoconch is strongly ribbed, with close-set smooth vertical ribs. Toward the end faint spirals in the form of crenulations appear between the ribs but do not cross them.

The conch begins abruptly with strong revolving spirals, and rather indefinite rib-like folds or undulations. These are far apart, but in the later whorls they become more prominent and defined. During the nepionic stage they are uniform from suture to suture, but

in the neanic and ephebic stages they are strong and stout in the middle, and fade toward the sutures. From the fact that about half of each whorl is covered by the succeeding whorl the ribs appear to be strong just above the suture and fade toward the upper portion of the whorl.

FIG. 22. *Cosmolithes uniplicatus.* The protoconch. (M. C. Z. 1127.)

Intercalated spirals appear in the second or third volution of the conch. The columella is furnished with one strong and one weak plication.

This is the *rugosus* type of the present genetic series. It is characterized by the strong sharp spirals, which are like those of *Clavilithes rugosus* and the other "rugosus types" of the various genetic series studied. The spirals are crowded and weak on the shoulder, but strong and well spaced on the body of the whorl. The whorls embrace to near the middle, the shells thus assuming a short depressed spire. The aperture passes gradually into the canal, without the sudden constriction seen in *Clavilithes rugosus.*

FIG. 23. *Cosmolithes uniplicatus.* Another view of the protoconch and young shell stages. (M. C. Z. 1127.)

The erection of the protoconch and the strengthening of the weak upper columellar plication produces *Rhopalithes.* In this connection a specimen of *R. rugoides* in the collection of the Philadelphia Academy is of interest (see above, p. 136), showing a more intimate relation between the two types.

A plicated columella appears to indicate a more specialized development than a non-plicate one. This is indicated by the fact that in the young the plications are often weak, and where two plications exist in the adult, the young sometimes show only a faint development of one, while the other is strong. From this it seems not unlikely that *Rhopalithes* is descended from *Cosmolithes,* and that the latter came from some Fasciolarian ancestor.

Localities: Grignon (M. C. Z. 1127); Paris (M. C. Z. 1133, 27770, 27782).

Horizon: Eocene.

COSMOLITHES SUBUNIPLICATUS sp. nov.

(Plate XIII, figs. 4–7.)

(Compare *F. uniplicatus* DESHAYES, Coq. Env. Paris, t. 2, pl. 94 bis, figs. 1–2.)

This species appears to be a derivative of *C. uniplicatus,* differing from that species chiefly in the more pronounced characters of the ribs which have more the form of strong undulations, but are more faintly marked by spirals. The upper weak columellar plication characteristic of the preceding species is also seen in some specimens of this

species, though in others only one strong columellar plication occurs. A posterior canal is developed on the aperture. Intercalated spirals appear in the early volutions of the conch. In some specimens intercalation is triplicate on the body whorl. This species is readily distinguished from the preceding by the fainter spirals and the undulatory character of the ribs.

Locality: Paris Basin (M. C. Z. 1134, 1130, 1129, 1128, 1132?, 27773) (Acad. Sci. 8035, Cossmann); Grignon (M. C. Z. 27772).

Horizon: Middle Eocene, Calc. Grossier.

COSMOLITHES LÆVIGATUS (Gmelin).

(Plate XIII, figs. 8, 9, 11.)

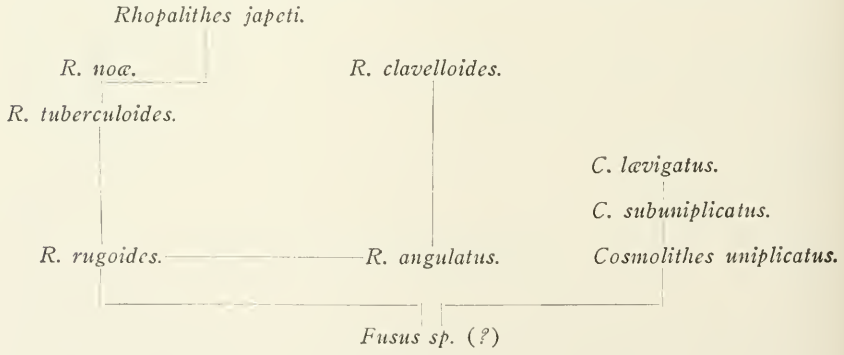
1788. *Murex lævigatus* Gmelin, Linn. Syst. Natura, Ed. 13, t. 6, p. 3555, no. 111.
1824. *Fusus lævigatus* Deshayes, Coq. Foss. Env. Paris, p. 531, pl. 70, figs. 14. 15.
1889. *Clavilithes lævigatus* Cossmann, Cat. Coq. Foss. Env. Paris, p. 175.

This species is closely related to the two preceding ones, from which it is distinguished mainly by the final smooth whorls. The protoconch and nepionic stage are as in the preceding species. The ribs are variously developed in the neanic stage, though they are seldom as strong as are those of the preceding species. In the ephebic whorls the ribs become obsolete. The spire is shorter and the aperture longer than in the preceding species. Lines of growth, crowded and lamellose, occur on the last portion of the body whorl, which is globose. The sutures are but slightly impressed, giving an almost uninterrupted slope to the spire. On the body whorl the spirals as well as the ribs are obsolete. Columella with a strong and a faint plication.

Localities: (?) (M. C. Z. 1122); Parnes (M. C. Z. 1121, 1123, 1126); Grignon (M. C. Z. 27771).

Horizon: Eocene, Calcaire Grosiere.

The relations of the preceding species may be expressed thus:



GEOGRAPHICAL DISTRIBUTION.

All the evidence so far obtained points to Western Europe as the place where the genus *Fusus* originated. The most primitive species of the genus yet found (*F. porrectus*) is from the Eocene beds of southwestern England.* The related French species (*F. aciculatus*) is, according to all appearances, a local modification of the primitive British species from which it has descended. As has been shown, the other so-called French Fusi probably all belong to distinct genera, as do also the species from the American Eocene beds generally referred to this genus. *F. unicarinatus* from France is probably not a true *Fusus,* but may belong to the genus *Falsifusus.* In no other Eocene formations have true species of *Fusus* been found, so far as I have been able to ascertain. Thus we are forced to regard the British Eocene seas as the ancestral home of the genus.

We have no certain knowledge of true species of *Fusus* in formations older than the Tertiary. Many Cretacic species have been referred to *Fusus,* but for the most part it is readily seen that these belong to other genera. There are, however, a few forms which need more careful study to determine whether or not they are to be considered as true Fusi. Kaunhowen described several species from the Upper (Maestrichtien) Chalk of Prussia (Gast. Maest. Kreide, pp. 81–83, pl. 9, figs. 9–11a; pl. 10, figs. 1–8) which, as far as the form is concerned, might well be considered true Fusi. This is particularly true of *F. bicinctus* Kaunh. Kaunhowen compares this species with *Fusus* (*Rhopalithes*) *angulatus* Lamarck, but this is probably merely a superficial resemblance. *Falsifusus* (*?*) *serratus* and *F.* (*?*) *unicarinatus* appear to be much more nearly related to Kaunhowen's species, and it is not improbable that these three species may prove congeneric. Of the other species described by Kaunhowen, *F. pliciferus* Binkhorst, *F. kunrœdensis* Kaunh. and *F. planus* Kaunh. deserve to be considered as possible ancestral types of *Fusus.* This is suggested by the simplicity of the whorls, particularly in the first of these, and the uniform character of the ribs, which recalls that of the young *Fusus.* The character of the apical whorls is, however, unknown.

We have at present too little information to enable us to trace the migrations of *Fusus* in time immediately succeeding the Eocene. The Oligocene species known from North Germany, if true Fusi, are the only European Oligocene species so far determined.

Miocene species of *Fusus* are known in Europe from the Vienna Basin. Strangely enough the species of this district, judging from the descriptions and illustrations—and the few specimens

* Cossmann cites this species from "la Loire inférieure" (Ess. de Paléoconchologie Comparée, T. IV, p. 4.

available—are like those of the sub-apennine formation of Italy, which is considered typical Pliocene. *F. rostratus, F. bredæ, F. semirugosus* and *F. longirostris* were, if anything, more advanced in the Miocene of the Vienna basin than they were in the Pliocene (?) of Italy. The similarity of development of the species indicates a connection between the Mediterranean and the Vienna basin during the Mediterranean stage and would also suggest that the deposits in which they are found are of the same age in both regions. In the Pliocene of Italy the genus *Fusus* is well represented by two series, the *F. rostratus* series and the *F. longirostris* series. The former continued to the present time, characterizing the Mediterranean province of to-day. The *F. longirostris* series appears to have ended in one direction in such forms as *F. castellarquatensis,* and in others, in *F. inæquicostatus* and *F. etruscus,* both of which probably represent terminal members of lateral branches. The two series were undoubtedly closely related, but their relation to the Eocene species is not so clear. It is extremely probable that there are as yet undiscovered connecting series, which flourished during Oligocene and Miocene times in a still unknown area.

If the progress of the Fusi in the Post Eocene of Europe is obscure, it is less so in the corresponding American formations. In the Miocene (or possibly Oligocene) of the West Indian region, we have good species which are not so far removed from the Eocene ancestors. These are *F. henekeni* and *F. haitensis* from Jamaica and San Domingo, the former a moderately primitive type, the latter more specialized, and representing a distinct branch. These are the earliest known species of the *F. colus* series, and they are very closely related to the Eocene species of Western Europe, though mostly growing to a much larger size. *F. eucosmius,* the modern offspring of these Miocene species, still lingers in the east American waters, having been dredged off Key West. Its nearest relatives, however, among the modern fauna, *i. e., F. turriculus, F. chinensis* and *F. recveanus,* are far removed from it geographically, occurring, so far as known, only in the China Sea region. The other members of the *colus* series are, however, distributed throughout the Indo-Pacific province. The easternmost recorded locality in the Pacific is Tongatabue in the Tonga or Friendly Island group about longitude 175° west of Greenwich, where *F. torcumus* has been found. *Cyrtulus serotinus,* however, the phylogerontic terminal of the *F. colus* series, has been recorded from Nukahiva in the Marquisas group, longitude about 140° west of Greenwich. The easternmost locality recorded for species of this series is Mauritius in the Indian Ocean, specimens of *F. torcumus* and *F. longicaudus* having been labelled as coming from the waters near that island.

From the data at present available it seems most probable that *Fusus* migrated westward across the Atlantic in early Tertiary times, and that it crossed the isthmus of Panama, during Miocene or Pliocene times, when that land body was submerged, and then, crossing the Pacific, established itself in the Indo-Pacific province, where it flourishes to-day. Thus the most typical Fusi, *i. e.*, the species of the *colus* series, appear to have migrated nearly around the world. It might of course be argued that the species of this series might have migrated eastward as far as the Indo-Pacific province, and that the Miocene and Pliocene members of the series are still awaiting discovery in Europe and Asia. This would leave the American species unaccounted for, since the hypothesis of a migration across the Pacific, in opposition to the prevailing currents, is hardly tenable. If it is assumed that migration occurred both eastward and westward, the very close similarity between the American *F. eucosmius* and the Chinese *F. torcumus,* which amounts almost to identity, is to be accounted for on a hypothesis other than immediate genetic relation. To sum up then, it seems most likely that the species of the *Fusus colus* series originated in the Eocene of Western Europe, and migrated westward during Tertiary times, until they have all but belted the globe, though their resting places were only at widely separated stages, where favorable conditions allowed development.

Turning now to the other series of *Fusus,* we find even more difficult problems indicated in their distribution. The *F. tuberculatus* series belongs wholly to the modern fauna, and is clearly derived from the *F. colus* series, probably through *F. torcumus. F. tuberculatus* is at home in the Indo-Pacific province, occurring on the east African coast and islands in the Red Sea, and on the Australian coast (Queensland). The northernmost branch of this series is at home in the Japan seas, this branch comprising *F. nodosoplicatus* and variety, and *F. perplexus* and varieties. From this latter series seems to have developed the Philippine Island representative of this group, *F. distans.* The occurrence of this latter species together with its descendant, *F. closter,* in the West Indian waters (Isle of Margarita) is a most perplexing circumstance. Is it possible that this species migrated around the Cape of Good Hope, up the west coast of Africa, and thence across the Atlantic to the West Indies? Or can we accept the much more improbable idea that the species migrated eastward, across the Pacific, and the submerged isthmus to its present location? The very slight differences between the West Indian and Philippine representatives of the species (*F. distans*) suggests that migration took place in the modern period, and one or the other of these paths must have been chosen unless we can accept the very improbable hypothesis of an independent origin of the species in the two waters.

The discovery of this species on the east African coast would go far to settle this question in favor of the westward migration of the species. As will be shown later, there seems to be little doubt that members of another series (*F. australis* series) of somewhat closely related Fusi have migrated along this path.

Another branch of this series, that of the large and beautiful *F. longissimus,* became widely distributed throughout the Indian ocean and the Pacific Island groups. The most specialized member of this branch, *F. undatus,* ranges from Ceylon on the west to Tahiti on the east, a range covering about 130 degrees of longitude, or more than one third the circumference of the globe.

From this same stock also originated the series of heavy or compact Fusi of which *F. beckii, F. laticostatus* and *F. nicobaricus* are typical. The first of these is a rare form, having been recorded from the Philippines only. Both *F. nicobaricus* and *F. laticostatus* are confined to the Indo-Pacific region, not having been recorded from west of Ceylon, or north and east of Liu Kiu (Loo Choo) off the south coast of Japan.

The members of the *F. australis* series have to all appearances descended from some member of the *F. tuberculatus* series, probably *F. distans. F. marmoratus* seems to be a direct descendant of *F. australis* and both occupy about the same territory. They are chiefly at home off the Australian coast, though they are more widely distributed in Indo-Pacific waters. A well-marked variety of *F. marmoratus* characterizes the Red Sea, but is not confined to it. This has probably given rise to the variable but characteristic *F. polygonoides* of the Red Sea, a species which has also been recorded from the East Indies.

Closely related to the Red Sea variety of *F. marmoratus* is *F. brasiliensis,* the American representative of this series. This has been found off the Brazilian coast, occurring as far south as Cape Frio, more than twenty-one degrees south of the equator. It is also recorded from the Florida coast, and specimens doubtfully labelled as coming from Suez have been identified with it. The migrations of this species, or its immediate ancestor, seem to have been around the Cape of Good Hope, and thence across the Atlantic. This may have been simultaneous with the migration of *F. distans.*

This brings us to the exclusively American *F. dupetit-thouarsii* and its various modifications. This species, at home only on the west coast of America, seems to have no immediate known Tertiary relative, unless *F. gabbi* be considered such. Its nearest living relative among the Asiatic faunas is *F. novæhollandiæ* from Australia and Tasmania. The occurrence of *F. dupetit-thouarsii* on the west coast of America suggests that its ancestors reached that coast during the Miocene sub-

mergence of the isthmus, and that we may therefore look for Miocene or earlier Tertiary ancestors of this species in the deposits of that age in tropical America. *F. gabbi,* though suggestive, is not conclusive, as the early stages of this species are unknown, and hence its relationship undetermined. *F. dupetit-thouarsii* var. *nodosus* is the most primitive representative of this series and from it all the other varieties were derived, as has been shown. *F. ambustus,* a west coast species, appears to be a lateral descendant from *F. dupetit-thouarsii nodosus.* Var. *irregularis* and *F. meyeri,* clearly derived from the more advanced members of the regular series of *F. dupetit-thouarsii,* are probably also west coast shells, though in collections the former has been labeled as coming from the East Indies. Considerable doubt is to be entertained as to the correctness of this locality, as the specimens were identified with *F. longirostris,* which it at home in the East Indian waters, and the habitat of which, together with its name, appears to have been arbitrarily applied to the specimens under discussion.

Having now traced the distributions of *Fusus* as far as the species have been studied, we may next inquire as to the probable method of migration of these organisms. Was it accomplished along a former continental platform, or was it across an Atlantic and Pacific like that of the present day? From what is known of the habitat of *Fusus* and its congeners, migration across the oceans on the present ocean bottom is out of the question, for all modern species occur only within moderate depths, being at home only in the littoral district.*

It is furthermore impossible, that migration should have taken place either along a north or a south Atlantic or Pacific shore line or continental shelf, unless wholly different climatic conditions existed at the time of such migration, for no true Fusi are known to exist outside of tropical or semitropical regions. Even if such conditions may have existed in the north or south Atlantic or Pacific during early Tertiary times, we have no evidence that they obtained in the modern period during which some of the most puzzling transoceanic migrations have taken place.

There seems thus no way to account for the migration of these organisms except by flotation during the larval period of their development. Nothing is known, so far as I am aware, of the early stages of true *Fusus.* Whether it has a free meroplanktonic veliger stage, or whether as is the case in closely related types, especially *Fulgur* and *Sycotypus,* this stage is passed through within the egg capsule, has still, I believe, to be determined. If the free veliger stage exists,

* The author follows Ortmann in the definition of the term littoral, including in it the "Flach See," or all that portion of the sea bottom which is effectively illuminated by the sun's rays. Though variable, the limit of this depth is in the vicinity of the hundred-fathom line.

transportation across the oceans, by the equatorial currents, would seem an easy matter, and the world-wide distribution of the genus within the equatorial belt would thus readily be accounted for. If, on the other hand, the veliger stage should be passed through within the egg-capsule as in *Fulgur,* or if, what seems not improbable in such accelerated types as *Fusus,* the veliger stage is dropped out altogether in the development, the problem of transoceanic migration by flotation becomes a much more serious one. In that case we have to assume that the egg-capsules, either separately or attached to sea-weeds, were carried by the equatorial currents across the oceans, and become stranded in favorable localities, where the young developed and appropriated the territory.

The development and migration of the Eocene Fusoid mollusks of other genera (*Falsifusus, Clavilithes,* etc.) present problems apparently as perplexing as that of the true Fusi. As has already been shown, the American waters contained no true Fusi though species of Fusoid form existed. *Falsifusus* may have been derived from a *Pleurotoma* stock, from which stock also *Levifusus* appears to have originated. *Euthriofusus,* the structural parallel of the latter genus, in the Miocene of Europe, was perhaps derived from the Eocene Pseudofusoids of the Paris basin. *Fulgurofusus,* the Eocene relative of *Fulgur,* may have been derived from a Fasciolarian stock. From a like stock, *Heilprinia,* was also derived, which during the Miocene submergence of the isthmus, spread on both sides of the American continents. Considerable doubt may be entertained as to the genetic relation of *Fusus serratus* Desh. and *F. uniangularis* Desh. of the Parisian Eocene with the Pseudofusi of the Gulf state region. I am strongly inclined to believe that their similarities indicate parallelism, rather than relationship, and that they have arisen independently, and so belong to distinct genera, a conclusion also suggested by their structure. When we take into consideration the provincial character of the faunas of which the Parisian species and the American Pseudofusi respectively were members, it seems difficult to believe that any communication could exist between the two regions. This suggestion is not at all invalidated by the occurrence of Clavilithoids in both the Parisian and the Gulf State Eocene, for, as has already been suggested, it is not at all improbable that the two series have originated independently, and that their striking similarities are merely pronounced cases of parallelism. *Cyrtulus serotinus,* of the modern fauna, is certainly as close to the Parisian *Clavilithes* in the characters of the adult as the latter is to the American species referred to that genus. Yet *Cyrtulus serotinus,* I believe, has no genetic connection whatever with *Clavilithes,* being a phylogerontic *Fusus,* and clearly derived from the modern members of that genus, while *Clavilithes,* though possibly

derived from an Eocene *Fusus,* nevertheless, belongs to an entirely distinct branch. As has been shown, there are constant differences between the protoconchs and young conch of the American and Parisian Clavilithoids, and these differences appear to be due to genetic distinctness.

I believe that the Lower Eocene *Clavellofusus* is the phylogerontic derivative of an Eocene *Fusus,* just as the modern *Cyrtulus* is the phylogerontic derivative of a modern *Fusus.* It is not improbable that *Clavilithes,* essentially a middle Eocene genus, was derived from *Clavellofusus,* though this point is by no means clearly determined. In fact, *Clavilithes rugosus,* the radical of this series, in all but the elongated protoconch, approaches *Fusus* and may have been independently derived from that genus. The derivation of the various species of *Clavilithes* of the Parisian Eocene from the radicle *C. rugosus* has been traced, the series being a remarkably complete one.

Nothing so much argues for the provincial character of the Paris Basin fauna than the distinctiveness of the species of *Clavilithes* which it embraces. In the closely adjoining British water no identical forms existed, a marked individuality characterizing all the species. That there was a barrier between the two neighboring localities seems unquestionable, but that barrier was probably not land; nor was it absolutely insurmountable. Nevertheless, those forms which did transgress the limits of the province within which the series developed, were either specifically modified or soon developed characteristics which pointed to a degeneration. It is highly probable that the barrier was merely caused by change in the facies of the Eocene sea bottom, which change is clearly indicated in the lithic character of the corresponding deposits. The north German Oligocene province was less distinct in facies or fauna from that of England, and the intermigration of species was probably more pronounced.

The Eocene of the American Gulf States had likewise its distinct series of species which paralleled those of the Paris basin. The succession of characteristics in the American as in the French species is such a normal one, and the series in each case fall so naturally into species marking the successive stages in development that we need not be surprised to find the specific characters identical, though characteristics of a higher taxonomic value maintain a constant difference. In other words, the same species marking the same stage in the development of the series occurs in both genetic groups. In the several Eocene provinces of France two other distinct series of phylogerontic fusoid gastropods originated most likely from a *Fusus* radicle. These were *Rhopalithes* and *Cosmolithes.* Both have distinct generic characteristics, but in each series, species occur, which parallel those of *Clavilithes. Rhopalithes* has a typical *Fusus* protoconch, and is probably not far

removed from *Fusus*. The plaited columella is a distinctive feature, but one which might be readily acquired in a strongly accelerated genus. The origin of such plaits has been discussed at length by Dall.*

Cosmolithes shows a modification of the protoconch which is depressed and more of the nature of the early whorls in *Clavilithes*. It probably was derived independently from *Fusus*. It is unknown outside of the French Eocene provinces.

* Tertiary Fauna Florida, vol. III, p. 58.

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EXPLANATION OF PLATES.

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(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge. The catalogue numbers are given. The illustrations are slightly reduced.)

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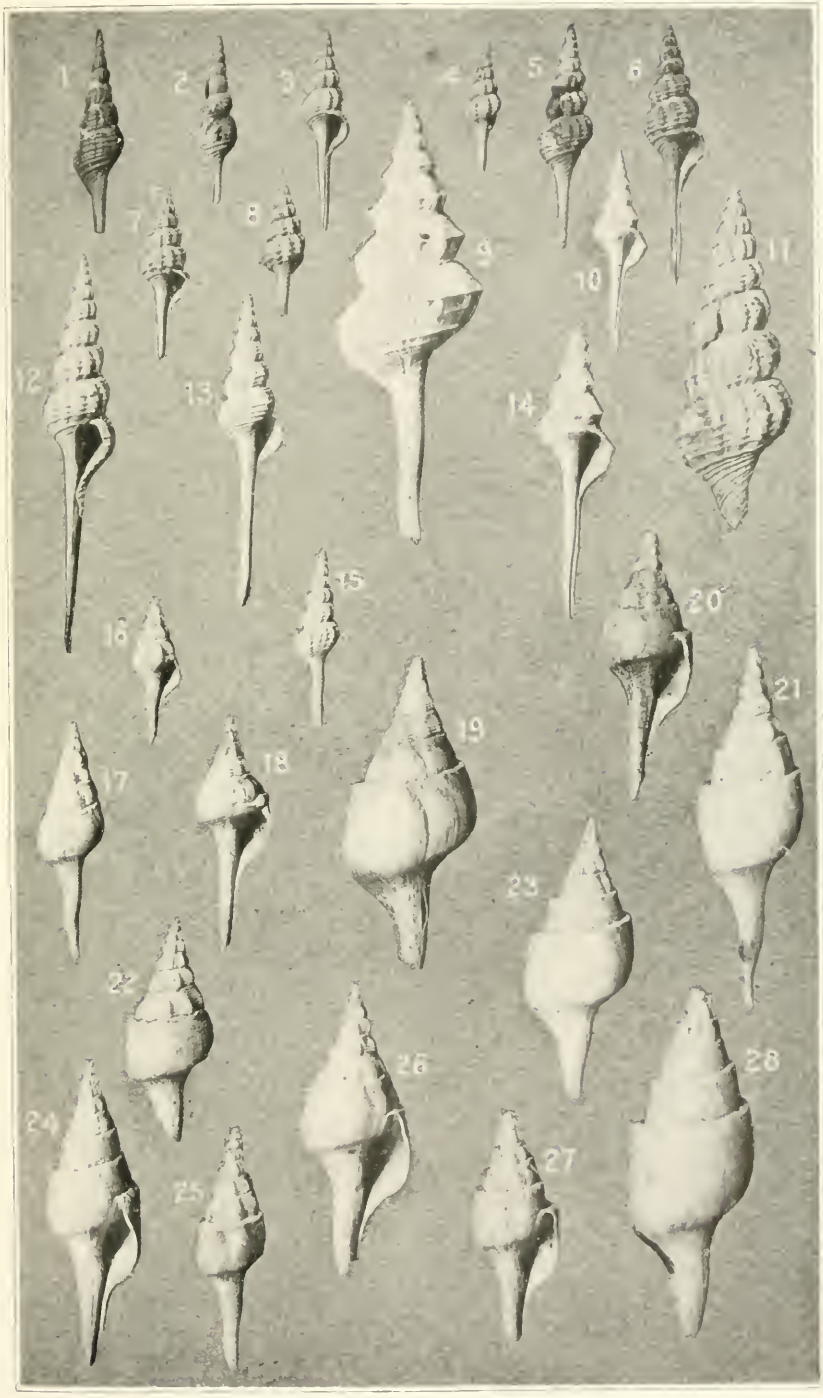

TERTIARY FUSUS AND CLAVELLOFUSUS.

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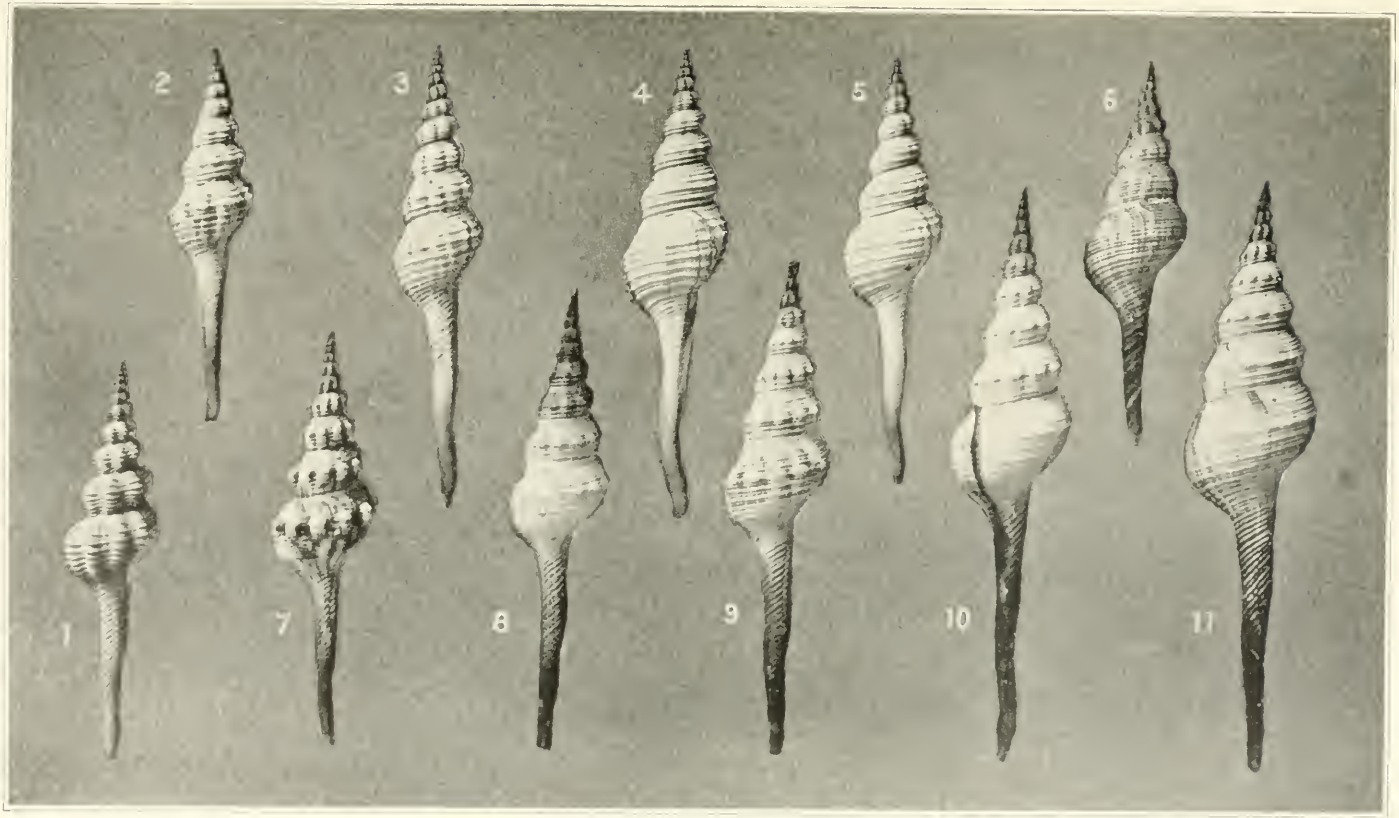

RECENT SPECIES OF THE FUSUS COLUS SERIES.

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(M. C. Z., Museum of Comparative Zoology; B. S., Museum Boston Society Natural History. All the illustrations are reduced.)

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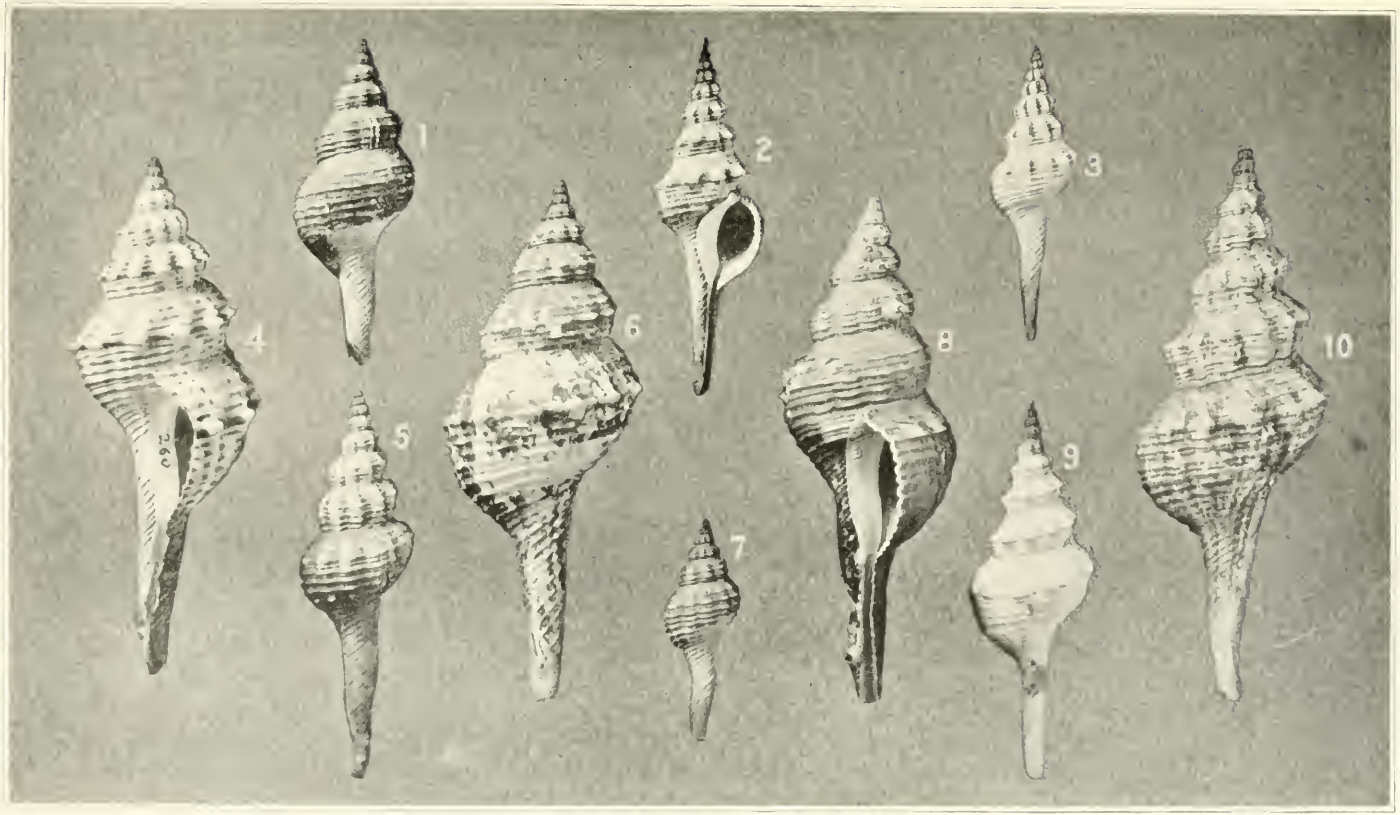

RECENT SPECIES OF FUSUS.

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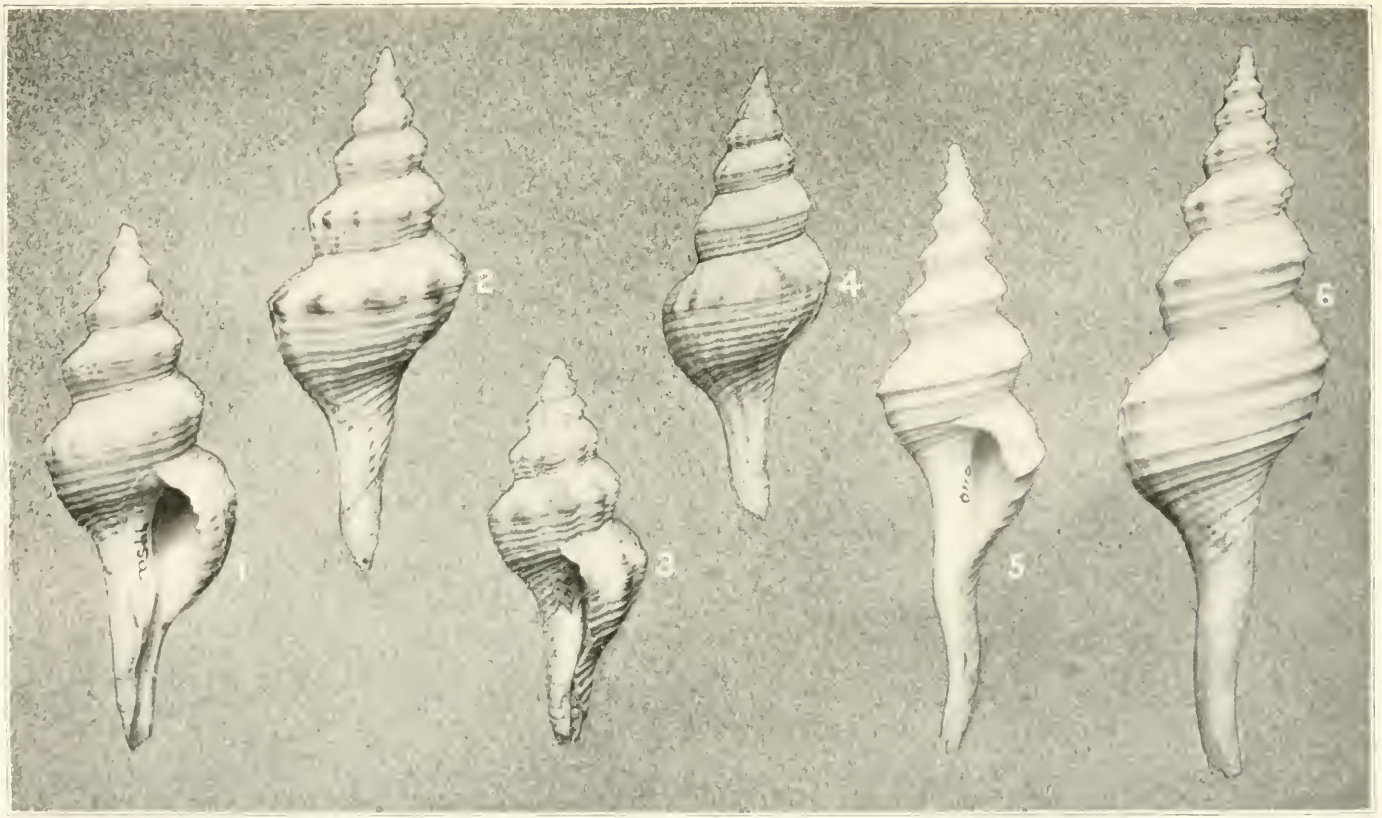

RECENT SPECIES OF FUSUS.

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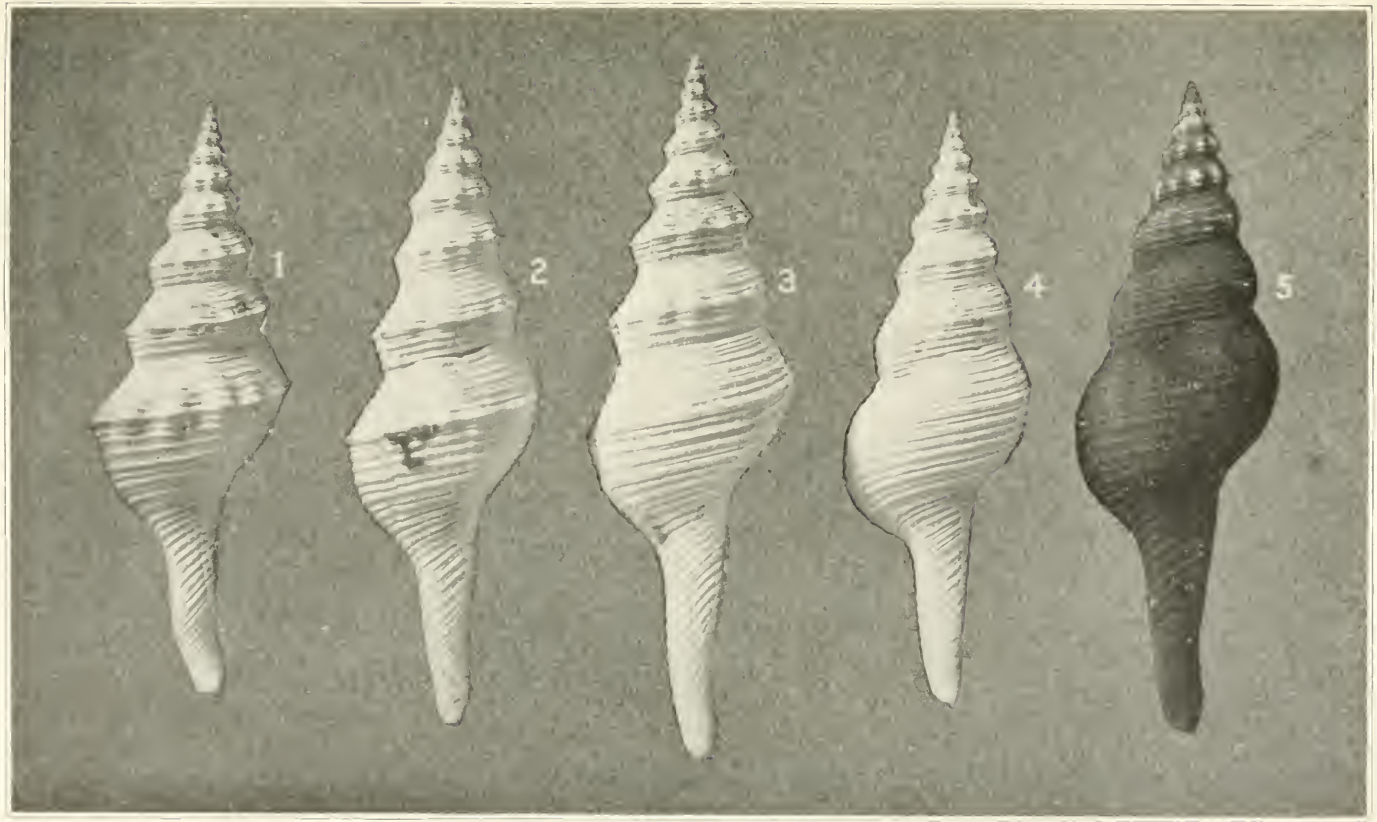

THE FUSUS DUPETIT-THOUARSII SERIES.

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(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge. The illustrations are reduced.)

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TERTIARY SPECIES OF FUSUS.

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(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge. The illustrations are slightly reduced.)

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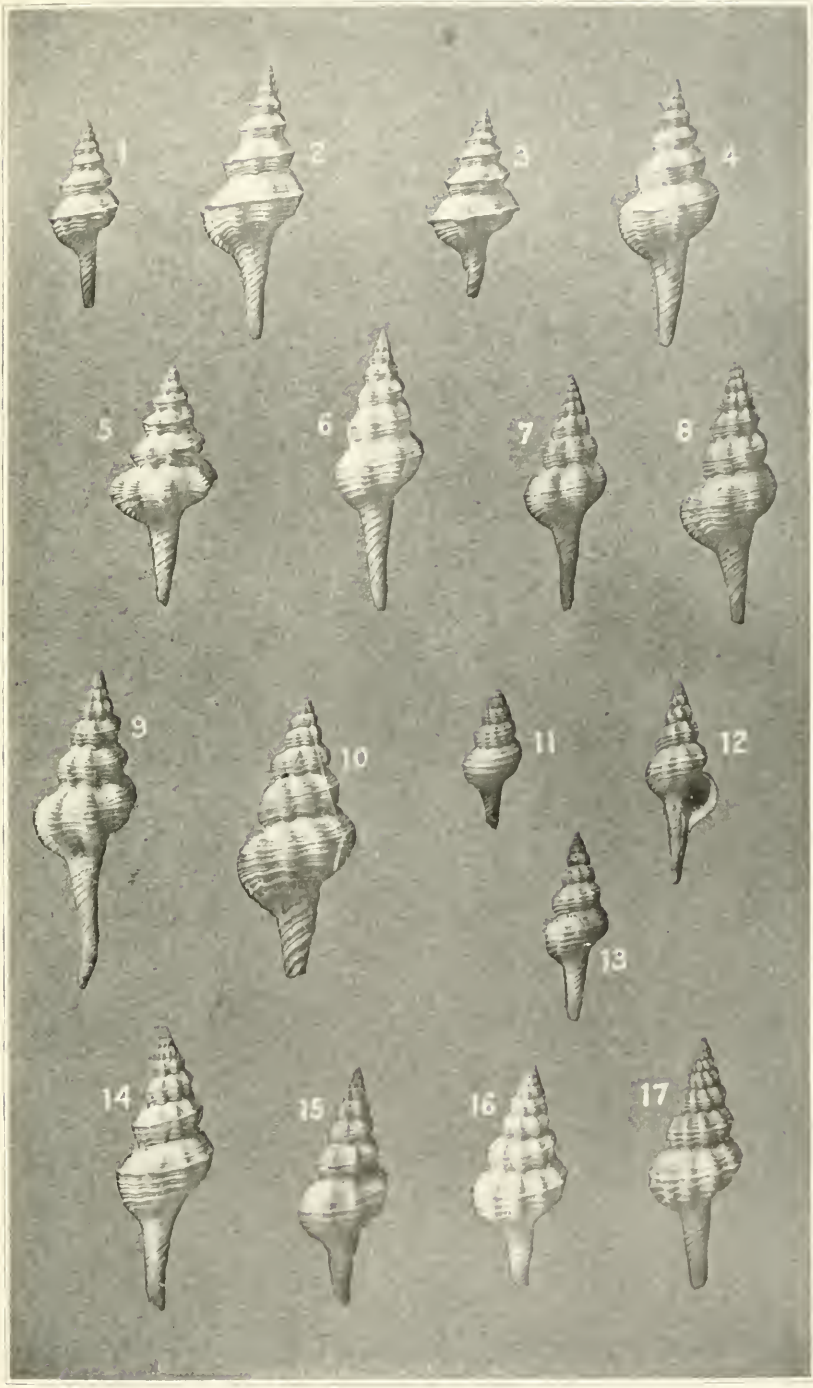

TERTIARY AND RECENT SPECIES OF FUSUS.

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(All the specimens are in the Collection of the Museum of Comparative Zoology at Cambridge. The illustrations are slightly reduced.)

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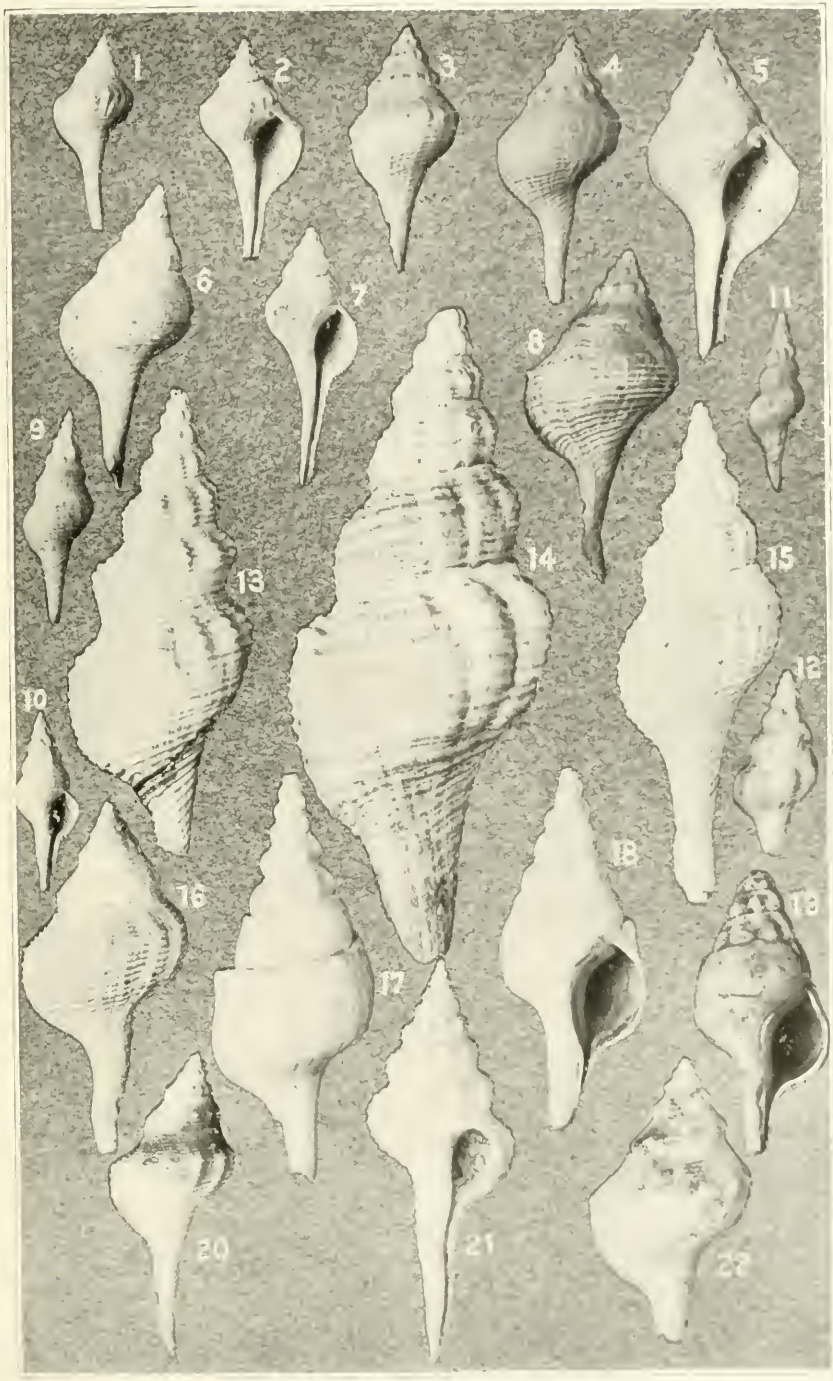

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(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge. The illustrations are reduced.)

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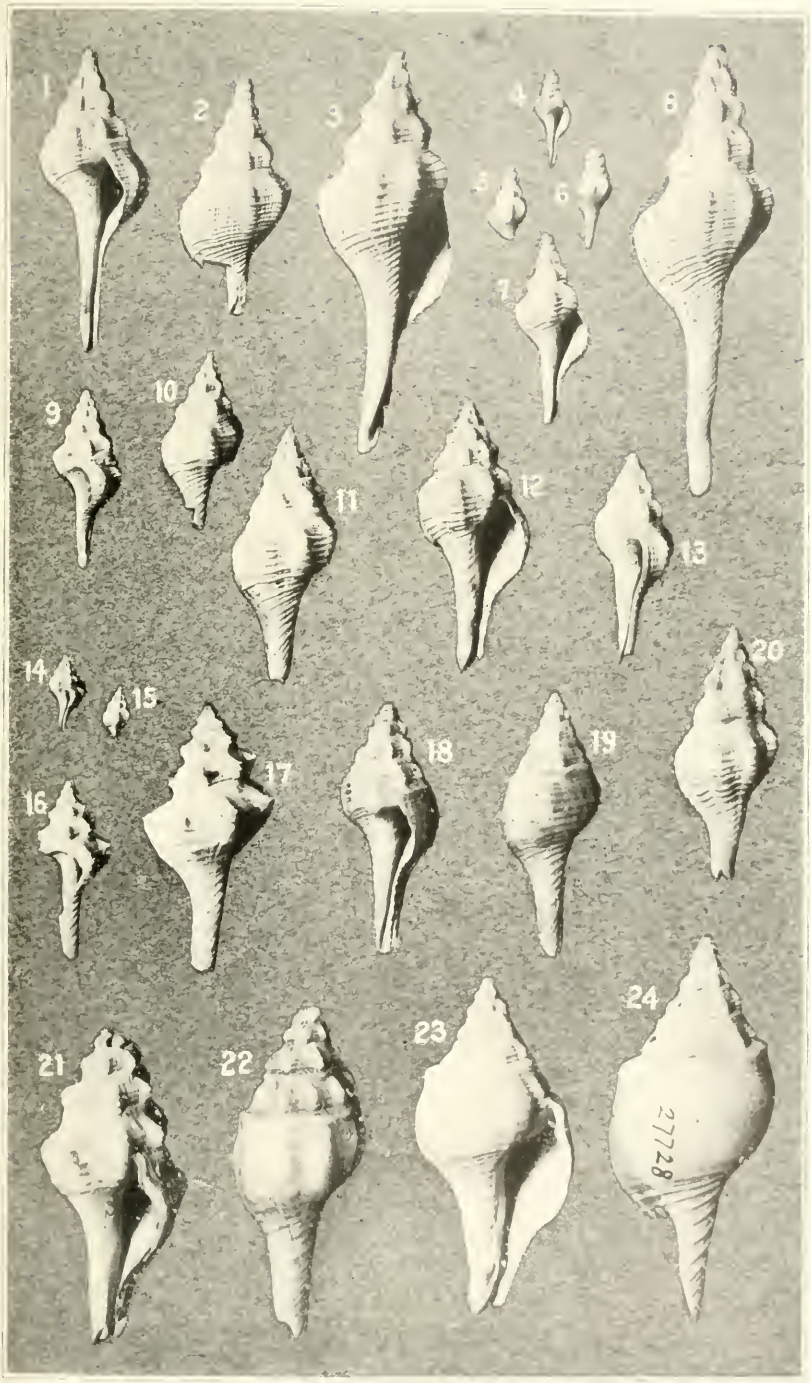

CLAVILITHES, RHOPALITHES, AND COSMOLITHES.

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(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge. The illustrations are slightly reduced.)

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SPECIES OF CLAVILITHES.

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(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge. The illustrations are slightly reduced.)

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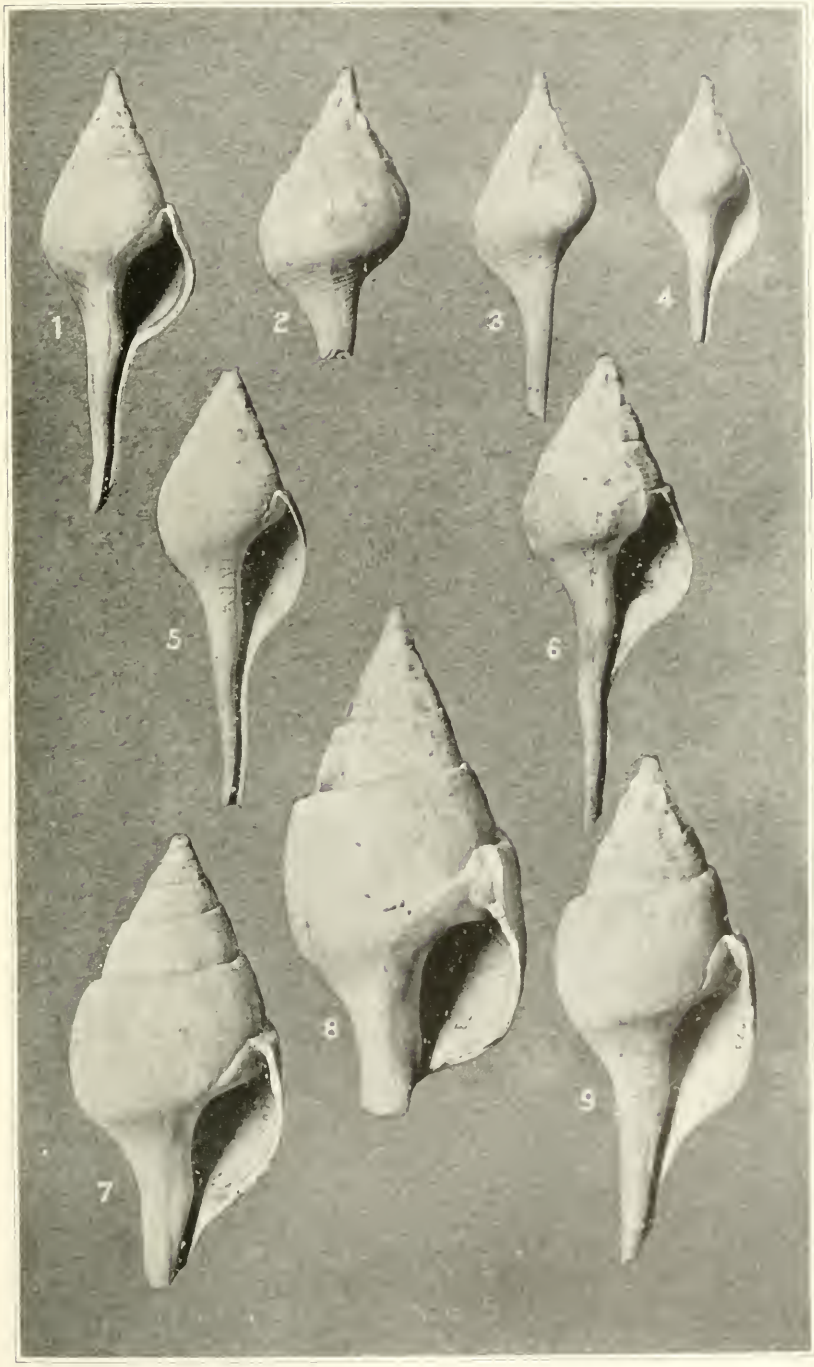

PARISIAN SPECIES OF CLAVILITHES.

Plate XII.

(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge. The illustrations are slightly reduced.)

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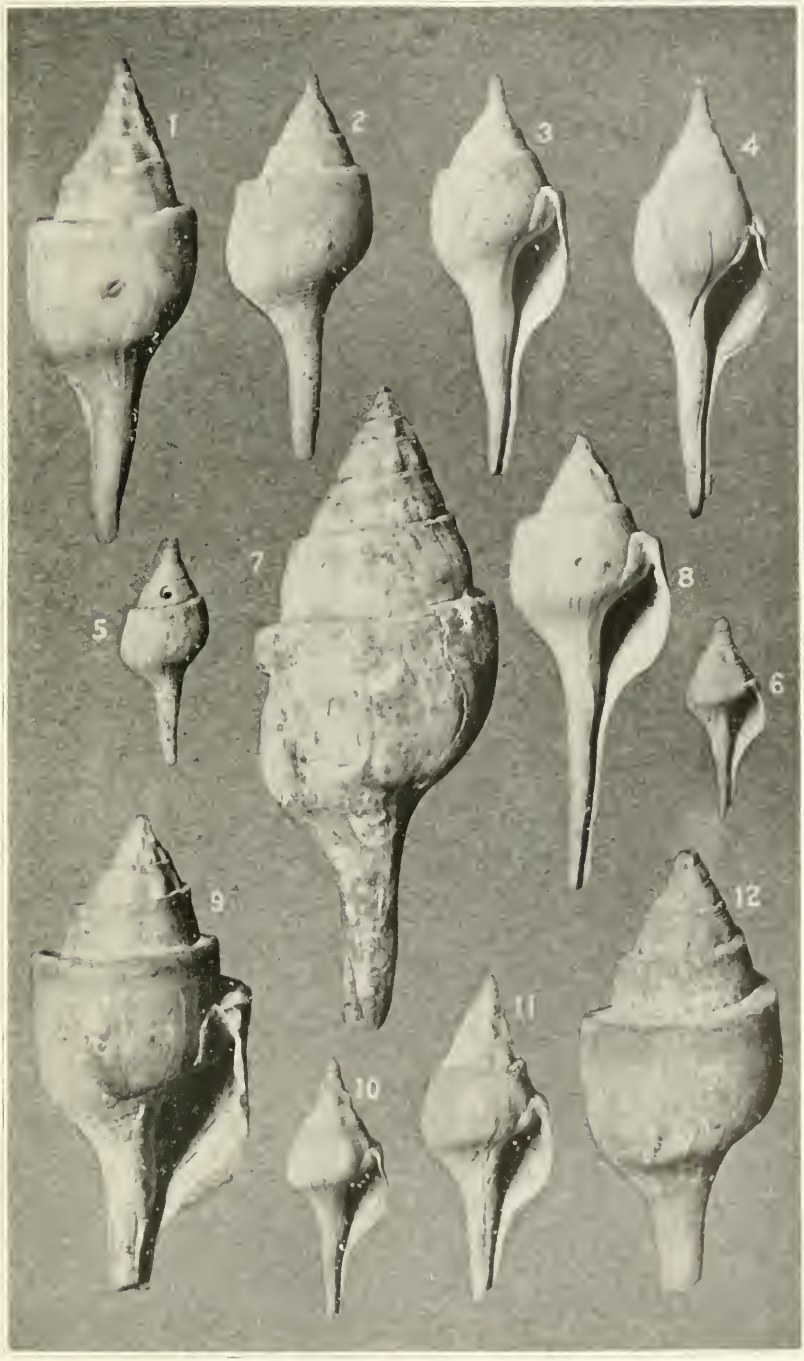

SPECIES OF CLAVILITHES.

Plate XIII.

(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge. The illustrations are slightly reduced.)

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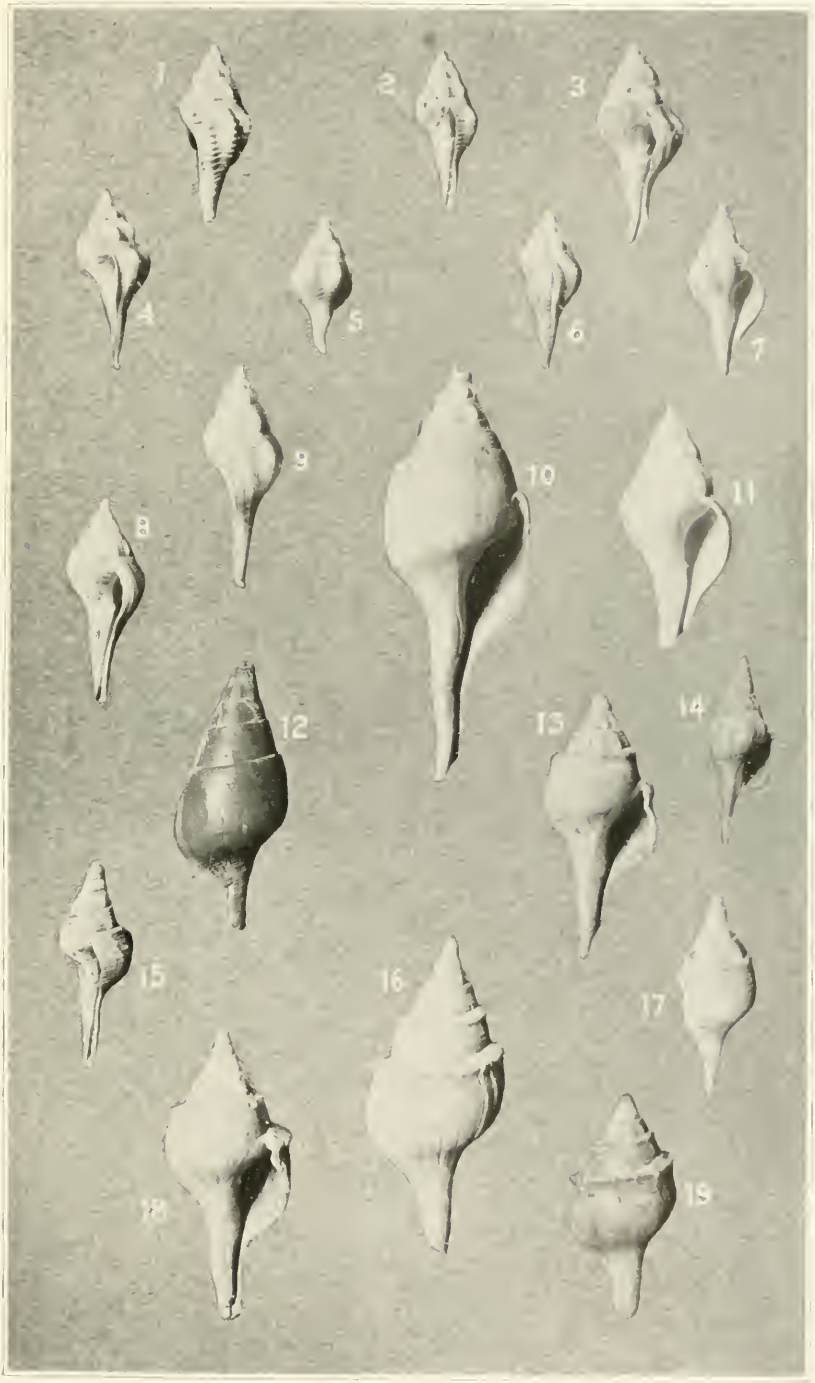

SPECIES OF COSMOLITHES AND CLAVILITHES.

Plate XIV.

(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge.)

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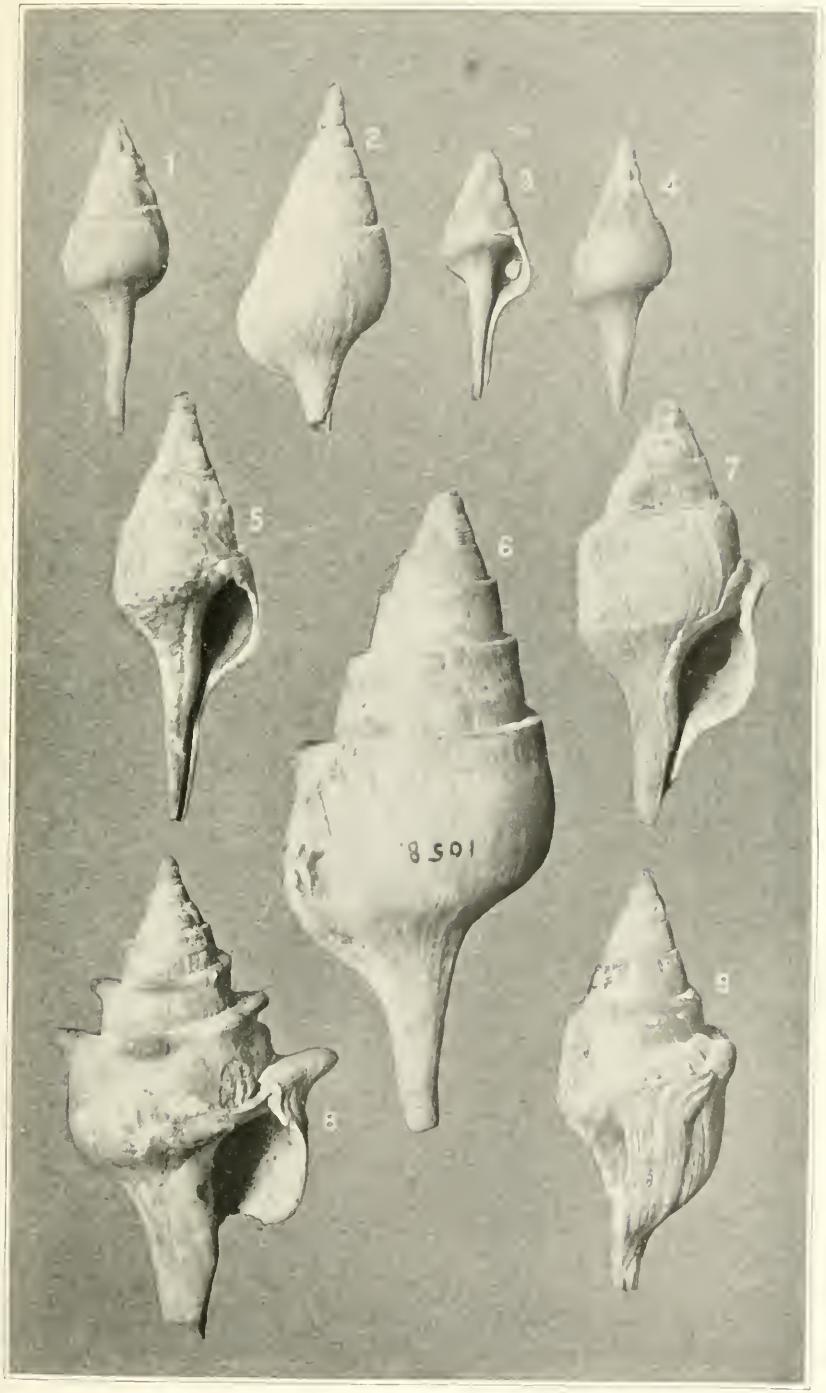

BRITISH SPECIES OF CLAVILITHES.

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(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge.)

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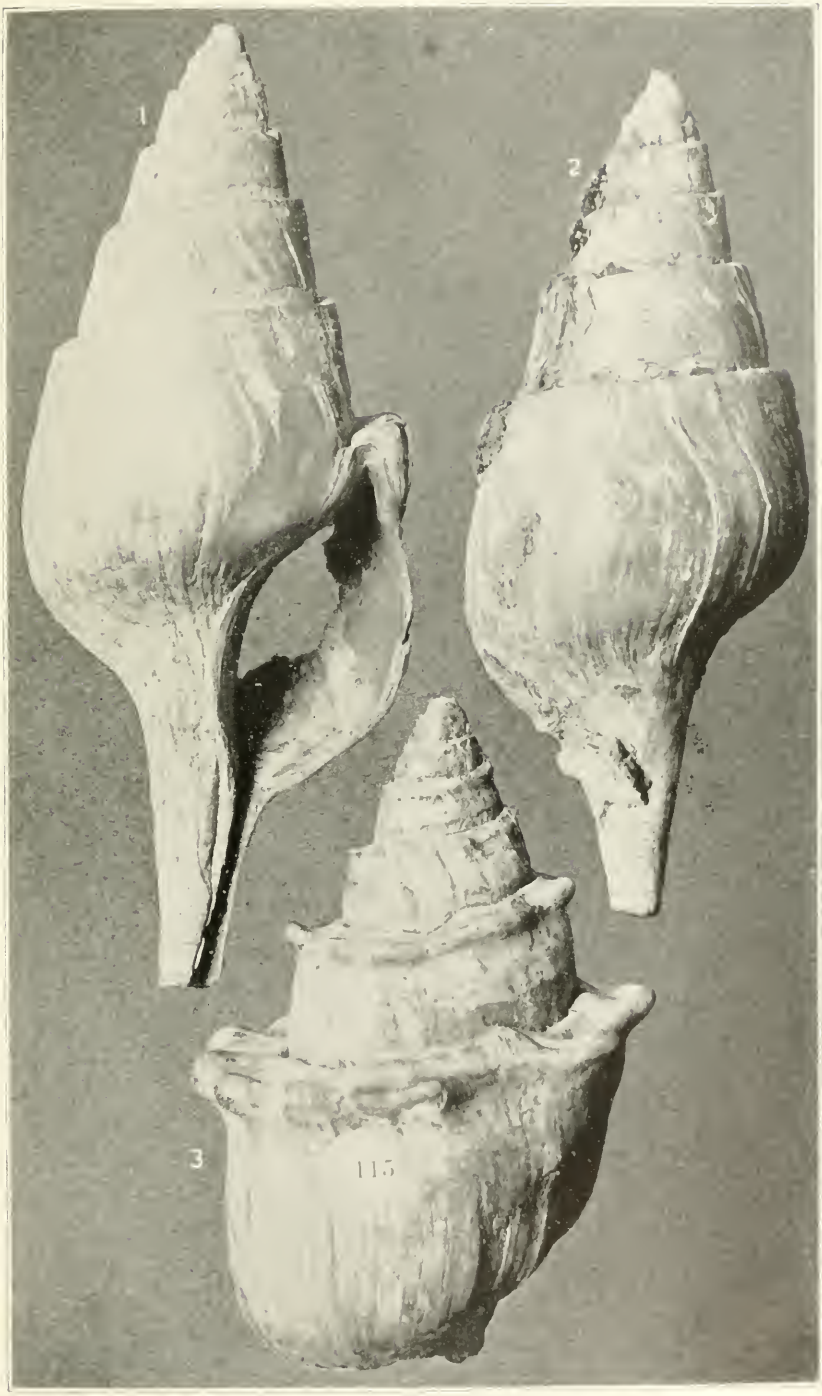

BRITISH SPECIES OF CLAVILITHES.

Plate XVI.

(All the specimens are in the collection of the Museum of Comparative Zoology at Cambridge.)

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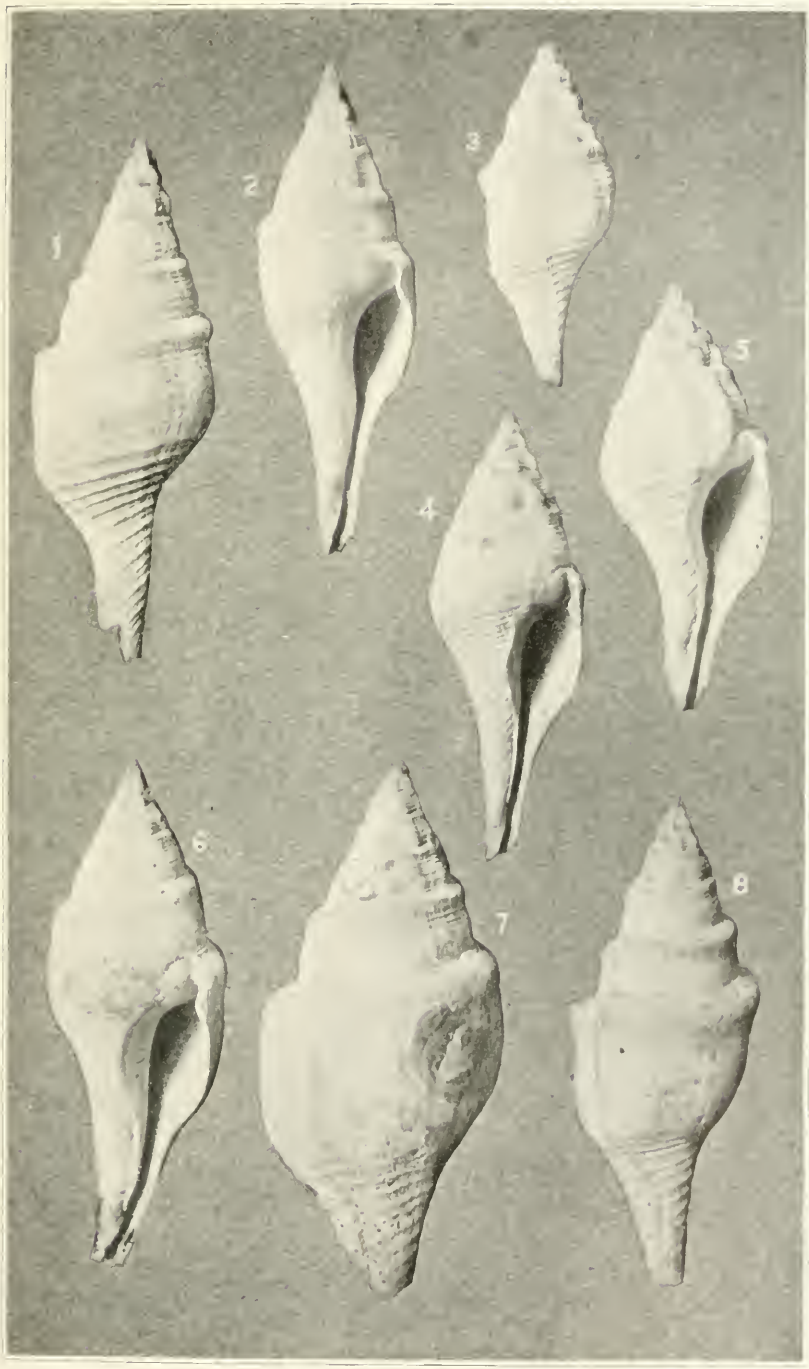

RHOPALITHES NOÆ.

Plate XVII.

Protoconch and Early Conch Whorls of Fusoid Shells.

(Drawn by Miss Elvira Wood, U. S. G. S., Washington, D. C., formerly Instructor in Palæontology Massachusetts Institute of Technology.)

(M. C. Z., Museum of Comparative Zoology, Cambridge; Acad. Sci., Museum of the Academy of Sciences, Philadelphia; Nat. Mus., National Museum, Smithsonian Institution, Washington, D. C.)

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PROTOCONCHS AND EARLY CONCHA WHORLS OF FOSSIL GASTROPODA

Plate XVIII.

Protoconchs and Early Conch Whorls of Fusoid Shells.

(Drawn by Miss Elvira Wood, U. S. G. S., Washington, D. C., formerly Instructor in Palæontology Massachusetts Institute of Technology.)

(M. C. Z., Museum of Comparative Zoology, Cambridge; B. S., Museum of Boston Society of Natural History; Acad. Sci., Museum of the Academy of Natural Sciences, Philadelphia; Nat. Mus., National Museum, Smithsonian Institution, Washington, D. C.)

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PROTOCONCHS AND EARLY CONCH WHORLS OF FUSOID SHELLS.

SMITHSONIAN MISCELLANEOUS COLLECTIONS.
PART OF VOL. XLIV.

A SELECT BIBLIOGRAPHY OF CHEMISTRY 1492-1902.

BY
HENRY CARRINGTON BOLTON.

SECOND SUPPLEMENT.

(1440.)

CITY OF WASHINGTON:
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1904.

WASHINGTON, D. C.
JUDD & DETWEILER, PRINTERS
1904

PREFACE.

THE SELECT BIBLIOGRAPHY OF CHEMISTRY, 1492–1892, was published in 1893; the First Supplement, published in 1899, brought the literature down to the close of the year 1897. The present work, constituting the Second Supplement, continues the subject five years later, to the close of the year 1902; in it are preserved the same subdivisions adopted in the main work, and it includes additions to Section VIII, Academic Dissertations, which was published separately in 1901. To summarize, the present work contains titles of books published between 1898 and 1902, both inclusive, under the following heads:

I. Bibliography.
II. Dictionaries.
III. History.
IV. Biography.
V. Chemistry, Pure and Applied.
VI. Alchemical Literature in the 19th Century.
VII. Periodicals.
VIII. Academic Dissertations.

No attempt has been made to *index* books and periodicals, as this is accomplished in the International Catalogue of Scientific Literature, directed by the Royal Society, London, and that undertaking is not duplicated in the present work.

HENRY CARRINGTON BOLTON.

WASHINGTON, D. C.,
FEBRUARY 27, 1903.

[NOTE.—Doctor Bolton died November 19, 1903, while this publication was in press, and most of the proofreading, as well as the preparation of the index, was done by Mr. Axel Moth, of the New York Public Library.]

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1492–1902.

SECOND SUPPLEMENT.

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SECTION VII.

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EXPLANATION OF SIGNS.

+ Following a date signifies current at the date in question.
Following a date signifies publication discontinued.

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SUBJECT-INDEX.

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This index is limited to special topics and does not include works of an encyclopedic character.

Sections I and III are partly self-indexed. Sections IV and VI, being entirely self-indexed, are not included.

Single letters and numerals denoting orientation and isomers are omitted in the index.

For terms beginning with Allo- and Ana-, see under the words to which these syllables are prefixed.

Words are spelled in accordance with the Rules adopted by the American Association for the Advancement of Science in 1891, and published by the United States Bureau of Education, Washington, D. C.

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